ENGINEERING

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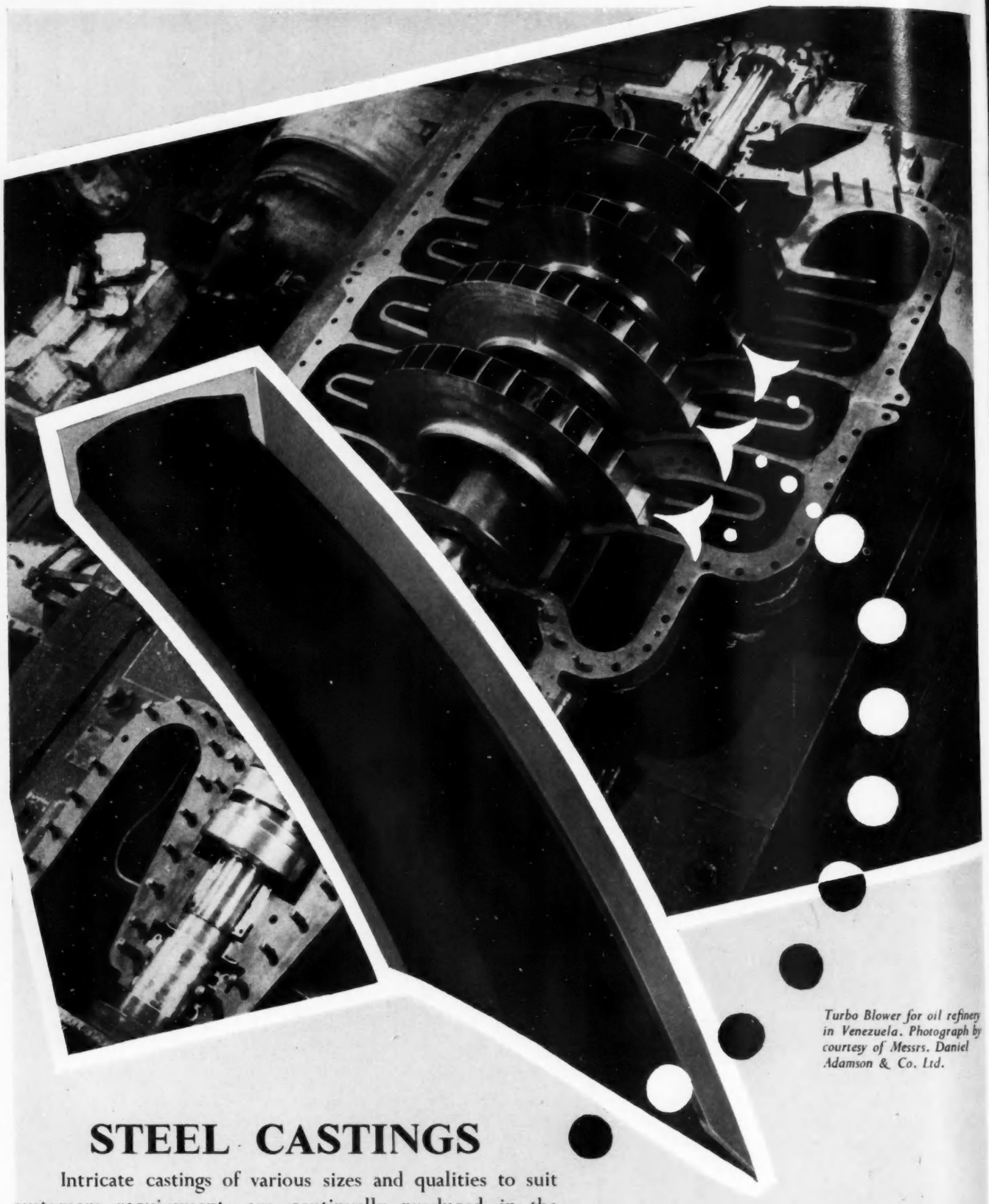

Turbo Blower for oil refinery in Venezuela. Photograph by courtesy of Messrs. Daniel Adamson & Co. Ltd.

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Comes a Time

THIS is a time of troubles, and troubled times bring neighbours close together. Britain and America have a most important property in common, a common language, for (with certain imperfections) the Americans have chosen to speak English. Yet some would say this only serves to emphasise the strange and alien nature of their habits. But are they so remote? The setting is unfamiliar, the traditions polyglot, but our beliefs are basically the same—"We hold these truths to be self-evident . . ." And the very Declaration that made them independent from us exemplifies the heritage we share.

There is a tide in human sympathy, whether it be on a national or individual scale; and quite outside the policies of governments, a new and friendly feeling for America has begun to flow in Britain. The British have always reserved the right to be rude to their friends but take offence when others are. We could not restrain a certain impudent delight when last September American assurance was taken down a peg, but when Mr. Khrushchev scoffed, it seemed in very doubtful taste. Now that America has been beaten to the draw in launching an earth satellite, been hit by a business recession at a time when the uncommitted nations are watching with calculating eyes, and her representatives abroad have been attacked by churlish mobs, the average Englishman is likely to feel a growing sympathy.

It was in this belief that ENGINEERING decided to send a representative to the United States, and in this issue the first part of his report is published. He came back reassured as to the competitive position of United States science and engineering. In a visit to Russia last year he was impressed with the blossoming of Russian engineering, but in spite of particular Soviet successes and statistics on the relative rates of capital construction, he saw no reason to doubt that America could meet the challenge. The U.S.A. has two immense assets: one is a rage to live; the other—a recessive factor though no less significant—he will attempt to describe in the course of his articles. The report reviews current thinking in the United States; it aims to discover where this thinking leads.

Historical perspective may make the difference between East and West seem trivial, as the murderous rivalries of Guelph and Ghibelline now seem to us. Our own age may be remembered rather as one in which the riches of the earth became available to an ever increasing proportion of the earth's population; in which science and engineering made power and protein sufficiently abundant for the first time in human history; in which new methods of communicating and processing information transformed society; in which men came closer to God in their powers yet further from God in their weaknesses. Eventually the air of contest may disperse. But meanwhile we should preserve whatever is good in all our various ways of life. In the West, we should recognise our kinship in tradition and culture, and understand that real conservatism which Carlyle described as lopping off the dead branch to preserve the living tree.

Kinship is not the same as integration, and each living branch contributes to the life of the tree. The American novelist, Mr. John Dos Passos, told our representative that when he was young he had hoped Canada would become a member of the United States. Now he was glad it hadn't: each different country with its own special character added something of interest to the world. Sometimes it seems that America is encroaching more and more upon us and that we are in danger of losing our identity. But character that cannot persist in company is hardly worth preserving.

Some see the progress of the United States as a magnificent parade down the primrose path, a mob in splendid motor cars with banners bearing slogans like "Why pay more when you can have a Ghouler funeral," or "Halitosis is better than no breath." But the predatory persuasive efforts of the men from Madison Avenue are deceptive. Behind the brash declamatory hoardings the people show a mixture of diffidence and optimism, with a trace of systematic doubt. There is an air of responsibility and heart searching, particularly among younger people. These are qualities we understand more easily than those for which Americans have hitherto been celebrated. The complacent British attitude that we alone are mature seems to be true no longer. Inside every fat man, it is said, a thin man is struggling to get out. Even the jokes in *The New Yorker* have the wry air of jokes familiar in *Punch:* an angry mob with sticks and banners is marching through a middle eastern gateway; a mild looking man with a briefcase has evidently stopped one of them to ask the way. The Arab, grasping an ugly looking club, turns to him. "The United States Embassy?" he says, "just follow us. We're on our way there right now." It is humour we can appreciate. We have had troubles, too.

Cover Picture. *Not one, but twenty-five pictures—a random sample of visual impressions from a visit to the United States. In this issue we start a report which our representative has prepared on current American thinking in education, science, engineering, management and business.*

* * *

Plain Words

Blessed are the peacemakers. Blessed indeed. When I look at the newspaper headlines, I conclude that the desire for fame, even notoriety, leads some men to prolong an argument, to avoid a quick settlement, and to remain locked in a struggle because it makes them appear active, determined, very important people. They could not play to the gallery if I, along with other newspaper readers, did not enjoy reading about people of that stamp. It is part of our daily ration of excitement. The Forum is all very well for the serious minded, when they are serious; but when they are not, and for the rest of us at all times, the Colosseum is the thing. The ultimate folly arises when the Forum is conducted like the Colosseum.

It is nearly 30 years since a large section of the population of this country were bitter and disillusioned because of their frustrating idleness. They marched in hunger marches and grasped at any political doctrine that would offer release from their wretchedness. But memories are short, and many who were children then or were as yet unborn, have grown to manhood now and cannot see beyond the newspaper headlines. How could they? Have we not allowed even the war to pass through the filter of our memories, so that now we are always ready to feed on the remembered greatnesses? Each man has his own private picture gallery, his own war museum, and he returns to it again and again in the solitude of his own mind.

And so it is with the events of nearly 30 years ago. They have lost their power to give us sanity and a sense of proportion. For those who remember, it is a bad dream; and for those who knew not, it is part of history. We are in June, 1958; and in June, 1958, men will fight not only for their rights but for their privileges too. That is why I toast the peacemakers. Like the Unknown Warrior, they are nameless. Their friends and adversaries know them, but no one else. They seek a settlement, not the limelight. Is there nothing we can do to commend them? They are, I assert, the truly great servants of our time. The trade union leaders and the industrialists who reach agreement without getting into the national news, who do not allow themselves to be drawn into a public squabble, are the men I am thankful for.

Yet I know that tomorrow I will feed on the headlines and watch the petty drama of well-known faces on my television screen. I am the guilty one and I am ashamed to admit it. Can nothing be done to change me?

CAPRICORN

Weekly Survey

Little by Little

Like a good many examples of successful international economic co-operation, the Colombo Plan continues to make gradual if somewhat unspectacular progress. One of the most encouraging aspects of the scheme has been the way in which this country has been able to increase gradually (one might say almost doggedly) its contribution under the Technical Co-operation Scheme. This scheme has been the means by which the United Kingdom has provided training places in universities, technical colleges and industrial undertakings for overseas students to acquire up-to-date knowledge, has supplied experts to help train local personnel and provided equipment to expand training and research facilities in South-East Asia.

Since the scheme began in the autumn of 1951 the intake of trainees in this country has increased annually from 50 to 453 and the 2,000th has just arrived here. There are now 459 trainees in Britain of which 155 have come from India, 100 from Pakistan and 83 from Ceylon. The remainder are made up from Burma, Thailand, Philippines, Indonesia, Nepal, Malaya, Cambodia and Laos. As at March, 1958, 38 per cent were studying social sciences, 20 per cent science and technology and 11 per cent engineering. The rest were studying agriculture, architecture, education and medicine. There were in addition 44 Indian students working in the British iron and steel industry and these are the vanguard of 300 to be trained for the Durgapur steelworks at present under construction by a British consortium in India.

Unfashionable Restrictions

There has been increasing pressure of recent weeks to establish some kind of international restriction scheme for certain commodities. Last month the United Nations' Commission on International Commodity Trade was criticised by the Chilean delegation to the United Nations for being slow and ineffective. As often happens in these matters, the Commission has been concerning itself with statistical studies while the countries affected by a surplus of such metals as copper, zinc, tin and foodstuffs want immediate action.

The position of the United Kingdom Government was made clear at the time of the Budget debate. The president of the Board of Trade said on that occasion that, having examined restriction schemes for individual commodities, the Government has come to the conclusion that this country's efforts should be concentrated on reinforcing world demand and replenishing the world's liquid reserves. In other words, this country is looking towards a better distribution of the free world's liquid resources to stimulate international trade and not to reductions in production if these mean the establishment of further international committees to operate restriction schemes. The Government is of the opinion that no restriction scheme can work for long unless the United States takes part and this country is concerned at the moment to persuade the United States to help in a redistribution of the free world's resources, rather than by pressing for international restriction schemes.

Too Many Tankers?

Although the earning capacity of tankers is at a very depressed level and the number laid up had reached over 4½ million tons in mid-April and was still rising, an extraordinary number of new tankers are under construction. This spate of building is the aftermath of the Suez crisis. Vessels on order throughout the world total some 36 million tons compared with an existing fleet of 51 million tons. Deliveries of new ships will build up to an annual tonnage of 8·7 million tons in 1959. This is an unprecedented rate which can only lead to a combination of scrapping, laying-up and cancellation of orders.

The number of tankers on order from British shipyards is greater than for any other country. Purely on tonnage, however, the lead goes to Japan whose orders include 10 tankers of 100,000 tons or upwards. Of total orders, some 14·3 million tons are for oil companies and the remaining 21·7 million tons for independent operators. If oil imports into the United States remain subject to limitation, the American oil companies will find it difficult to employ all their new tankers.

Of the 36 million tons of tankers now on order 27 million are in the "super" or "monster" class of vessels of 30,000 tons or over. This emphasis on size and performance is bound to result in a surplus of smaller tankers which can be of real use only in times of emergency. It may be that the industry may use this reserve to protect itself against excessive market fluctuations, unexpected contingencies and future political crises.

Buying Advanced Knowledge

A postgraduate course in applied dynamics has been running for the first time in the present academic year at the University of Edinburgh. It forms part of the Department of Engineering. The object is to give an advanced course in dynamics combining a fundamental approach to theory with an emphasis on practical application. It has been felt that the study of analytical dynamics has not always developed in a way suitable for practical needs at a time when modern advances, notably in aircraft and missiles, call for a grasp of dynamic analysis which is beyond the scope of an undergraduate course.

The course runs over the nine months from October to June and in addition to lectures and the work connected with them, each student undertakes a small research problem and the report on this work is taken in conjunction with the final examination results in deciding whether a diploma shall be awarded. Experience so far suggests that the general framework of the course is satisfactory but here, as in other fields of postgraduate work, the scheme has run up against the difficulty of offering a course requiring some degree of intellectual maturity with financial grants to students which cannot compare with industrial salaries.

This is one more case of the need to reconcile postgraduate research work and mature practical application of fundamental work with reasonable financial reward. It is quite out of the question to expect the State to subsidise postgraduate work on the necessary scale to provide attractive salaries to postgraduate research workers over the vast technical field which is now opening up. There is therefore probably no alternative to companies themselves releasing promising young men for these kinds of courses. Even this solution, however, brings nearer the time when there will have to be some form of stocktaking on the subsidisation of academic work by commercial undertakings.

Energy Problems of the Six

The sixth report of the High Authority of the European Iron and Steel Community states that there is in hand the preparation of an energy policy for the Six. This follows on from its existing studies of coal resources. The object of the exercise will be to chart short and long-

term needs and weigh up with the optimum combination of advantage as regards dependability and price for the various alternatives. Consumer choice as to the most suitable form of energy to use will be one of the guiding principles in drawing up policy. Efficiency ratings, flexibility of supply, and investment costs are other important factors. Excessive differences in arrangements as between one country and another and one product and another will have to be eliminated. Here the difficulty is to ensure that the user pays the true cost for a service.

Another job involving a comparison of the practices of the different countries is the study which the High Authority is making of wage structures, incentive bonuses, and methods of wage negotiation. As the report shows that the big manpower problem of the Community has been to retain an adequate number of underground workers it is important to find out what sort of incentives are most effective. The principle that the miner's pay and terms of employment should place him " in a privileged position in relation to other industrial workers " is proving increasingly hard to implement.

The Price of Simplicity

An examination of the consequences of a change-over to the metric system in this country is to be made by a study group under the chairmanship of Sir Hugh Beaver. This committee has been set up by the British Association for the Advancement of Science. The terms of reference are: " To report on the practicability, implications, consequences both international and domestic, and the cost of a change-over to the metric system or the decimalisation of weights, measures, and coinage by the United Kingdom." Sir Hugh will have a committee of nine including representatives from two engineering firms and one consulting engineer.

The latest convert to the metric system has been India which went over to it on 1 April 1958. It is indeed possible that the trend of economic events over the next few years may give an additional impetus towards standardisation on the metric system. In Europe, for example, the establishment of the Common Market and the possible advent of a Free Trade Area will produce further arguments for those exasperated Continentals who have for long complained that the British system is a vexatious waste of the clerical time. At one time the British system of coinage and its complicated denominations in weights and measures was the price which the world paid for the security and convertibility of sterling in world trade.

One of the complications from the point of view of British companies is that some concerns, and there are examples of it in the engineering industry, have spent much time and money successfully impressing upon customers throughout the world the virtues of accepting British standards. If the metric system is adopted it may well be a major step towards the elimination of British standards, at least so far as notation is concerned, in a wide variety of products. There is an apparent simplicity for many people about the decimal system that is like the Promised Land. It is probably wonderful when you get there but it is at the end of an arduous journey.

World Standards

For the first time the triennial meeting of the International Standards Organisation is being held in Britain—at Harrogate, from 9 to 21 June. Fifteen of the technical committees are to meet, including the newest, that on nuclear energy. The president at the meeting will be Sir Roger Duncalf. Adoption of common standards makes for easier trade between countries and for such items as aircraft servicing is indeed essential.

Technical committee No. 1, which deals with screw threads, will be concerned with the adoption of the two parallel ranges (inch and metric) proposed at the Lisbon meeting; it is hoped that agreement may be reached on this point. At Lisbon the efforts to agree on a single series met with a very narrow defeat by 11 votes to 10, and more consideration on the proposition may be given at Harrogate. The nuclear committee will be mainly concerned with problems of protection for the workers in establishments and for the public at large.

The international aspect is to the fore in the choice of standard sizes of pallets for through traffic between countries—a problem beset by many thorns—and in the adoption of a marking to indicate conformity of goods to ISO requirement. The enormous increase in the traffic in tinned goods has raised the issue of tin sizes, with the object of preventing unfair trading by using containers of deceptive shape.

Of the 89 technical committees of ISO, Britain has the secretariat of 18, more than any other country. Since the secretariats are allotted on the basis of initiation of a standards project and involve a close control of the work in hand, this is a record to be proud of. The committees work separately under the co-ordination of the council. Understanding and agreement grow with time and the growth is logarithmic; there are now some 160 standards in draft form. As might be expected the older countries, that have internal standards of their own, are slower to adopt changes to conform to international agreement, but the growing countries are adopting the ISO standards from the first. Most of the newer British standards include ISO recommendations—indeed they have many times formed the basis of them.

Switzerland Joins GATT

Last week tariff negotiations opened in Geneva between Switzerland and 19 other countries, including the United Kingdom. This is the beginning to Switzerland's accession to the General Agreement on Tariffs and Trade. This move, though only at the preliminary stages, is a welcome formal sign of a more liberal attitude in principle on the part of Switzerland to European free trade.

It is only fair to say that Swiss trade liberalisation has been over 90 per cent since 1952, which compares favourably with the average level of 83 per cent for OEEC countries as a whole. In principle Switzerland has been opposed to the total abolition of quotas and restrictions and this reservation has for some years put it out of alignment with the declared policy of OEEC as a whole. Switzerland has always appeared as a somewhat reluctant participant in the movement towards freer trade in Europe and the continuation of the currency payments union operated by the European Payments Union under OEEC.

The swing in Swiss economic policy may owe something to the establishment of the European Common Market and the possibility of a Free Trade Area. Switzerland is not a member of the ECM but is a potential member of the FTA. It is of interest to recall that it was the Swiss watch makers' delegation which recently sponsored a favourable and successful resolution on the Free Trade Area at a recent meeting in Paris of the International Chamber of Commerce. Such a step as adherence to GATT would probably require a good deal of time to obtain parliamentary ratification but it can at least be said that if the Free Trade Area negotiations go any further during the summer the Swiss attitude is likely to be slightly more favourable in principle than it has in the past.

Power from Slurry

The West Fife Area of the Scottish Divisional Coal Board have announced that the new experimental power station at Bowhill, Ayrshire, which uses coal slurry, effected a saving of £66,000 during its first year's operation. It is claimed that this is the first British power station to use this type of fuel and that 35,000 extra tons of better quality coal have been released to industry and to the domestic market which would otherwise have been required to produce the power generated at Bowhill. The West Fife Area is planning to install two more slurry-burning boilers in the central power station at Kelty which, along with Bowhill, will supply all the electricity required by the 24 collieries in West Fife and will effect an estimated annual saving of £198,000.

The burning of slurry and other low-grade refuse from washeries and from material taken out when new underground roads are being driven or new coal faces opened up, has long been an object of policy not only in the coal-mining industry but also among those concerned with the enormous amount of new land required year by year to accommodate the waste material in spoil heaps—estimated by the Beaver Committee on air pollution to be about 750 to 1,000 acres a year. The Ayreshire developments have not been the only ones. For some years, experiments have been going on at Llay Main collery near Wrexham where a plant with an output of 50,000 lb of steam an hour is running successfully and economically and was recently duplicated. At Hams Hall C near Birmingham (see p. 729) some slurry is being burned. Slurry or filter cake from the coal-preparation plant at Barony colliery in Ayrshire is also used for electricity generation in the local power station.

From the point of view of industry, the regrettable thing is that these welcome technical improvements never seem to be reflected in any reduction in the prices of coal, the only consolation being that had they not been effected, coal would presumably have been even more expensive than it is.

Letters to the Editor

INDUSTRIAL TRAINING FOR OLDER PEOPLE

SIR, We are interested in the problems of training older people in industry, and at present we are engaged in collecting information about schemes which exist for the training of workers of 35 years of age and above.

We should be grateful if, through your columns, we could make our researches known to firms engaged in such training, and if we could solicit their help in providing brief details of training schemes.

Yours faithfully,
D. G. ENTWISLE.

Unit for Research on Employment of Older Workers,
The University of Bristol,
22 Berkeley Square, Bristol 8.
28 May, 1958.

ENGINEERS' SALARIES

SIR, I am sorry that Mr. Stanley Mayne, secretary of the Institution of Professional Civil Servants, takes exception to the fact of my having commented publicly on his circular to officers of the Institution about the Engineers' Guild and the Royal Commission on Doctors' and Dentists' Remuneration (ENGRG., 30 May, p. 675). It is, however, quite clear from the wording of the circular that the advice which it contains was tendered with the intent that it should be communicated to any member who sought guidance on this matter, that consequently there was no question of the subject matter being confidential, and that the evident purpose of the circular was to discourage co-operation in the survey. As I mentioned in my original letter (ENGRG., 23 May, p. 643), the questionnaires on which the survey is based have already been issued, so that " the public Press " provided the only available means of countering the criticisms which the I.P.C.S.,

Continuing Letters to the Editor

alone among the bodies concerned, has seen fit to offer.

With regard to Mr. Mayne's general remarks about Civil Service conditions I can only repeat what I said earlier, namely that he appears to be confusing fact and comment. To reiterate that salaries in this field are " depressed salaries " is no argument against ascertaining objectively what in fact are the average incomes and career prospects. It must also be remembered that the present survey is concerned with the engineering profession as a whole, in which the Civil Service is but one of several fields of employment.

Mr. Mayne persists in his wholesale criticism, both of the evidence already submitted by the Guild to the Royal Commission, and of the quite separate survey. It might be possible to answer his complaints about the former, and to dispose of his fears regarding the latter, if he had given any particulars of what precisely it is to which he objects. Indeed, had the Institution consulted the Guild at an earlier stage these matters could have been discussed between us and no doubt satisfactorily resolved. It is surely arguable that, having failed to take this opportunity during the past four months, Mr. Mayne's attempt to impede the successful execution of the survey, as it were from behind the scenes, is at least equally open to criticism on the ground of " questionable ethics."

May I, in conclusion, repeat what is said by my chairman of council in a covering letter to the persons included in the sample: " the facts about the economic position of the engineering profession are urgently needed to-day, and by helping to provide these facts you will be helping to further the interests of your profession." This is a national survey, being undertaken by the Guild in the national interest; the results will be made available to all who ask for them, and we believe that they will be of value to the I.P.C.S. equally with all other bodies which are concerned with the welfare of the engineering profession.

Yours faithfully,

J. G. ORR,
Secretary.

The Engineers' Guild,
78 Buckingham Gate,
London, S.W.1.
30 May, 1958.

Plant and Equipment

ELECTRONIC COMPARATOR

One of the items shown by Southern Instruments Industrial Division, Frimley Road, Camberley, Surrey, at the recent Production Exhibition was the Magna-Gage electronic gauging comparator which can measure to 0·00001 in with a total deflection of 0·005 in.

The instrument is small, robust and portable and being completely insensitive to normal mains and temperature variations can be used with maintained accuracy in any situation. It is simple and easy to use allowing operation by personnel without special skill.

Together with its accessories the Magna-Gage provides a flexible and versatile range of equipment for semi or fully automatic indication and control of dimension tolerances.

The sealed gauge head is guarded against damage as far as possible and can be mounted on a comparator stand or machine in any desired position. A flexible cable carries the electrical signal to the remote indicating unit which can therefore be placed in any convenient display position. The conversion of a physical change to an electrical signal gives endless possibilities and the equipment only requires simple adaptation for automatic control.

The signal light indicator attachment indicates tolerance limits by coloured light signals. This enables sizing or batch sorting of work-pieces to be carried out by unskilled operators. Relay outputs are also available from this same unit for automatic sorting or machine control. For example, in grinding machine control the first relay contacts can be used to change over to a lower rate of feed when the work is approaching size, and the second to stop the machine after size is reached. The pointer can be set to zero after the head has been mounted, and the limits indicated by the lights (and the associated relays) can be individually adjusted.

MINIATURE SERVO MOTORS

The size O7 servo motor now being made by Smiths Aircraft Instruments Limited, Cricklewood, London, N.W.2, is reputed to be one of the smallest in the world, measuring $\frac{5}{8}$ in in diameter and $1\frac{1}{2}$ in in length, and weighing $1\frac{1}{4}$ oz.

Developed from R.A.E. Specification EL1872, the motors are available in two versions. The standard type requires a 26 V supply to each phase, or a 26 V single-phase supply with a 1·5 μf tuning capacitor. The germanium transistor version incorporates a 26 V reference winding and a 20 V centre-tapped control winding supplied from two transistors; operating frequency in both instances is 400 c/s.

Minimum no-load speed is 9,000 r.p.m. and minimum stall torque 8 gm-cm. The rotor has an exceptionally low inertia of 0·18 gm-cm^2 allowing quick starting and stopping.

The stainless iron stators are fully encapsulated and the rotor laminations are stamped from corrosion resistant materials. The rotor shaft is supported in bearings lubricated from integral oil reservoirs and terminates in a standard pinion, approved by R.A.E. for use in size 07, 10 and 11 servo motors.

HEIGHT GAUGE

A stabilised height gauge made in five sizes, the largest being 48 in tall, was one of the items on the stand of James Chesterman and Company Limited, Sheffield 11, at the recent Gauge and Tool Exhibition.

The upright of the gauge is made from V-section steel which gives the necessary rigidity, and in the V is the full-length screw for the fine adjustment of the pointer. One face of the V is calibrated in inches and the other in centimetres; open verniers on both faces allow readings to be made to 0·001 in or 0·02 mm.

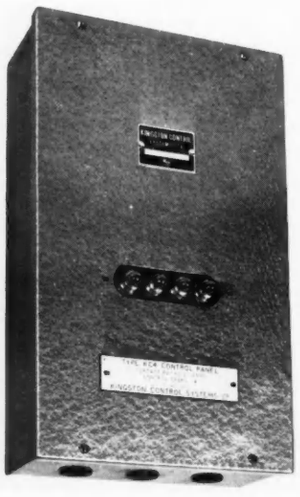
Quick adjustment of the height can be made by compressing two side lugs on the head which release the split nut from the screw thread. The latter is rotated by a knurled knob on the base to give the fine adjustment—an action which also serves to hold the base firmly down. The base itself is made extra heavy and lapped optically flat with a large bearing surface to retard wear. A notch machined in the rim prevents suction adhesion to the surface plate. The makers state that the rigidity is sufficient for even the 48 in model to be used without " blocking-up." The five standard sizes are: $1\frac{1}{2}$ in to 12 in; 2 in to 18 in; 2 in to 24 in; 3 in to 40 in; and 3 in to 48 in.

STABILISED CONTROL PANEL

The increasing use of air-conditioning and plenum schemes has caused an urgent demand for thermostatic controllers of greater sensitivity than those used hitherto for radiator or panel heating systems, due to the much higher rates of temperature change encountered. To meet the need Kingston Control Systems Limited, Empire Chambers, Richmond Road, Kingston-upon-Thames, have produced stabilised control panels (types KC and KR) which are equally suited for the control of room air conditioners sequence and selective schemes, chilled water tanks, electric heater batteries and other cases where accurate and precise control is required.

The illustration shows a Kingston KC4 four-step panel in direct control of a 16 kW heater battery. The space temperature is held by the setting of the room thermostat. Low and high-limit duct thermostats can be used as required. As the theoretical contact differentials is nil, setting between steps can be as close as $\frac{1}{4}$° F.

These panels have been designed for use with a selected range of high-sensitivity contact controllers. Both KC and KR panels can be supplied up to a maximum of four steps with thermostatic humidity and pressure controllers to suit. When, however, a greater number of steps are required special panels can be supplied subject to the availability of suitable multi-contact controllers. All the KC panels are



fitted with contacts rated at 20 A, 250 V a.c. (non-inductive) for direct control of heater and motor loads, and KR panels have contacts rated at 5 A for switching relay circuits.

COLLET CHUCK

The milling equipment made by Clare-Collets Limited, Altrincham, Cheshire, has been extended to include a collet chuck, the " G " size, to accommodate up to 3 in diameter parallel shank tools and 5 in diameter direct cone arbors.

This chuck is claimed to be the largest collet chuck made (8 in coupling diameter) and is for use on the larger milling and boring machines, where tool interchangeability is a vital necessity. Tool changes on the spindles of the large machines such as plano-millers are a major operation and can be responsible for much idle machine time. The wide tool range covered by the chuck provides a multiplicity of milling applications without having to continually remove the chuck from the spindle.

The chuck has parallel bore collets, $1\frac{1}{2}$ in, 2 in, $2\frac{1}{2}$ in and 3 in diameters and No. 5 Morse taper sleeves. A reducer chuck fits directly into the largest collet and covers from $\frac{1}{4}$ in diameter to $1\frac{1}{4}$ in diameter parallel and Nos. 1, 2, 3 and 4 Morse taper collets. The chuck can also be supplied with " through " (i.e., plain parallel) bore collets, standard or special sizes, for flange mounting on gear cutting machines.

Continuing **Plant and Equipment**

DUST EXHAUSTER

The latest addition to the T series of dust exhausting and collecting plant made by Keith Blackman Limited, Mill Mead Road, London, N.17, is the T.2500 unit, shown in the illustration. The range has capacities from 250 to 2,500 cu. ft of air per minute. The T.2500 unit is the first to be fitted with a new " snap-action " mechanical

The T.2500 dust extractor will serve four grinding machines with 10 in wheels.

shaking gear (being operated in the illustration) for dislodging fine dust trapped in the filters, the dust then dropping into the dust tray at the foot of the unit, the capacity of which is 5 cu. ft. All units will in future be fitted with this new shaking gear, with the exception of the T.250 in which it is unnecessary due to its type of filter.

The size of the T.2500 is 6 ft 6 in high by 3 ft wide by 3 ft deep. It will readily serve four reasonably spaced, double-ended grinding or polishing machines with 10 in wheels, or a medium size (5 ft by 2 ft 6 in front opening) scurfing or fettling booth.

10,000 GALLON SUPER FUELLERS

To meet the demand for an adequate fuelling service to the large American jet airliners shortly to come into service, the British Petroleum Company have placed an initial order for two " super " fuellers, with a capacity about three times that of the average airport fuelling vehicle.

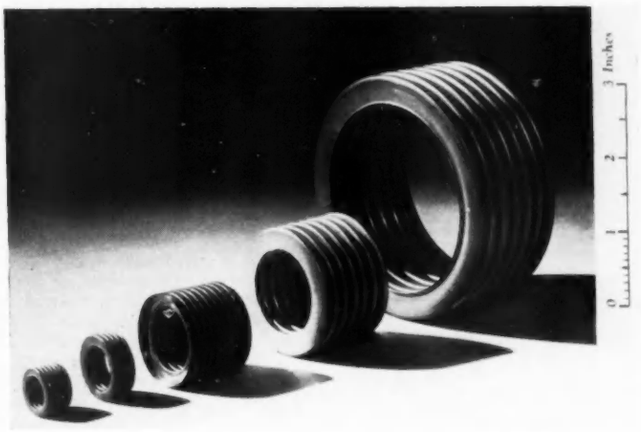
Contracts have been placed with Thompson Brothers (Bilston), Limited, Bilston, Staffs, and Saunders-Roe (Anglesey) Limited, Beaumaris, for the supply of two prototype " Yorkshire " fuellers each of 10,000 gal capacity, with a maximum flow capacity of 750 gal per minute each.

The fuellers are to be built on the semi-trailer principle with an A.E.C. tractor unit incorporating a 165 h.p. diesel engine. The wheelbase is longer than the normally-accepted tractor type in order to accommodate the pumping and delivery equipment behind the cab. The overall length of the vehicle is 49 ft 9 in and it is 10 ft 6 in high. The semi-trailer tank, in aluminium alloy, of 10,000 gal useful capacity will be divided into three compartments.

The equipment will include a newly developed self-priming centrifugal pump by Pegsons Limited, Coalville, and metering equipment by Avery-Hardoll, Chessington. To meet the high standard of filtration required for jet fuels, the fuellers will be equipped initially with Rellumit fine particle filters, and water-detection devices will be installed as an added protection against contamination. Pressure control equipment by Zwicky Limited, Slough, is also being utilised.

The Yorkshire fuellers are expected to be in service early next year.

HIGH PRECISION BAROMETRIC BELLOWS



For use in sensitive control mechanisms and pressure-sensing devices, a new range of high-precision seamless bellows, and complete tested bellows-assemblies, is now being offered by Avica Equipment Limited, Mark Road, Hemel Hempstead, Hertfordshire.

Avica precision barometric bellows can be produced in any of the conventional materials used for instrument and control systems, i.e. phosphor bronze; 80-20 brass, or aluminium brass alloys; and also in Monel, cupro-nickel and stainless steel. They are normally supplied in the cold-worked condition, but additional heat-treatment operations such as stress relieving or annealing may be carried out if required. Micro-hardness checks may be included as part of the high standard of quality control maintained.

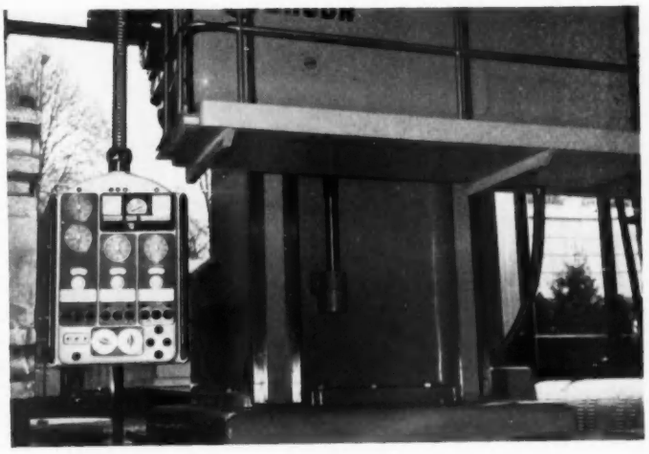
A tolerance in spring rate as low as $\pm$ 10 per cent can be provided, on a production basis; the dimensional tolerances are appreciably tighter than have previously been available; $\pm$ 0·005 in may be held for the external and internal diameters of the corrugations if required, and as low as $\pm$ 0·005 in on the diameter of the end terminations, if other than flush. At present, they can be produced over a size range from 3·8 in bore to 12 in bore. The bellows " ends " may be terminated in a number of ways to suit the installation and attachment of other components. The corrugations may be finished off flush, or may have tubular " cuffs "; the diameter and length of which may be varied infinitely, and between both ends of a given bellows. Bellows can be produced where practicable to customers' own design requirements, or alternatively will be designed and produced to meet each specific set of operating conditions.

CONTROLLING LARGE MACHINES

The illustration on the left shows a device for producing the punched cards that control a jig boring machine exhibited by the Russians at the Brussels Exhibition. The cards are divided into three sections. Numbers for the machine are calculated beforehand and set up by means of telephone dials; the numbers dialled are displayed in the rectangular windows above the telephone dials so that a check can be made that the correct number is being punched.

When the cards have been prepared, they are taken to the card reader, seen in the background of the illustration, which controls the boring machine. As all movements are in straight lines no interpolation between co-ordinates is called for. A 10 kW main motor is employed.

The illustration on the right shows the remote control panel for the control of a boring machine exhibited in the Czechoslovakian pavilion. Again the controls are divided into three to correspond to the three directions of movement. All movements can be controlled from this panel. The main motor of this machine is of 30 kW capacity.



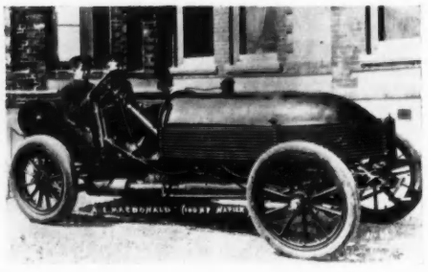
Companies in the News

150 Years Old

The name "Napier" to-day usually brings to mind the internal combustion engine, both in its reciprocating and turbine versions. In the 150 years that the Napier company has been in existence, however, they have in fact been responsible for a remarkable diversity of engineering products—examples of which can now be seen at their 150th birthday exhibition at the Tea Centre, Regent Street, London, W.1. The exhibition, which started on Tuesday, remains open until June 14.

The Napier family themselves—father, son and grandson—were prolific inventors. The Scottish founder of the firm, David Napier, set up a general engineering business in London in 1808. From 1820 until the end of the century, he became a leading designer and manufacturer of printing machines and minting equipment. He devised and patented a machine which could turn out 25,000 bullets a day, which was ultimately installed at the Royal Arsenal, Woolwich; and later he supplied the Royal Arsenal with heavy machinery such as cranes and a steam-driven gun-finishing machine.

His son, James Murdoch Napier, took over the management of the business in 1866. Among his inventions—on view at the exhibition—was an early example of automation: a machine which detected and rejected gold coins which had fallen below standard weight. In 1895 the business was taken over by James Murdoch's son Montague Stanley Napier, and started to thrive anew soon after M. S. Napier designed his first two-cylinder four-stroke automobile engine "of a dubious 8 h.p.," about 1898 or 1899. This began Napier's very successful entry into the motor-car industry; one of their early sporting ventures, the first six-cylinder racing car and the fastest car of its day (1904-1905) is shown in the accompanying illustration. The Samson car, as it was known, achieved a speed of 104·65 m.p.h. over the mile at Daytona Beach in 1905.



The first six-cylinder Napier racing car set up a 1 mile speed record of 104·65 m.p.h. in 1905.

With the advent of the first World War, Napier entered the aircraft and aero-engine field. The first aero-engine of their own, the 12-cylinder Lion, designed by Mr. A. J. Rowledge, which appeared in 1918, was for many years supreme in its class—on land, sea and air—and in fact it is still in marine service to-day. After the death of Montague Napier in 1931, Major F. Halford became design consultant to Napier, and designed the H-type aero engine series, culminating in the 24-cylinder Sabre which powered the Hawker Typhoon and Tempest fighters in the latter part of the second World War. By this time, the Napier company had been acquired by the English Electric Company Limited, who bought all the share capital in 1942.

Because they were concentrating on the development of the Sabre, Napier had some

Continuing **Plant and Equipment**

FORM GRINDING INTERNAL HELICAL GEARS

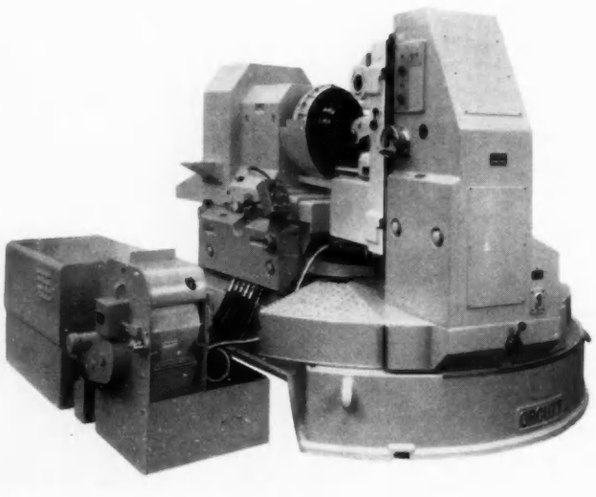
In response to a request from the aircraft industry the Gear Grinding Company Limited, Cranmore Boulevard, Shirley, Solihull, Warwickshire, have added to their "Orcutt" range of gear grinders a machine for precision form-wheel grinding of internal helical gears. Grinding both flanks of a tooth space simultaneously, the machine is capable of very high precision work, with surface finishes of 8 to 10 micro-inches. The principal capacity details are given below:

Minimum inside diameter of work	10 in
Maximum " " "	24 in approx.
Minimum number of teeth ..	45
Maximum " " ..	240
Minimum normal diametral pitch	10
Maximum " " "	5
Minimum helix angle subject	0°
Maximum " " to N.P.A.	25° R or L hand
Minimum lead of gear tooth ..	67 in approx.
Maximum " " " ..	Infinity
Maximum face width of tooth ..	4 in approx.
Maximum diameter of grinding wheel	8 in
Maximum depth grinding wheel will penetrate into hole ..	6 in

The machine consists of a base which carries the reciprocating workhead at one end and the grinding wheel head at the other. Separate hydraulic power and coolant supply and filtering units isolate the machine from the effects of oil temperature changes as much as possible. In operation the work head is reciprocated hydraulically while the work spindle receives a lead-generating motion from a unit housed in the work head, and the work is thus traversed across the path of the grinding wheel, which grinds both flanks of a single tooth space simultaneously. After each complete reciprocation of the work head the gear is indexed automatically by one tooth.

A fixture at the front of the work head holds the gear to be ground, and at the opposite end of the head is mounted an indexing mechanism, of which a pawl and a plate with the same number of teeth as the gear are the basis. Also at the rear of the work head is the lead-generating mechanism. This consists of a disc mounted on the work spindle and connected by steel tapes to a horizontal cross slide which, in turn, is equipped with four rollers straddling a sine bar. Graduated disc mounting of the sine bar enables it to be set to give the lead required for any particular gear, and as the work head reciprocates, the rollers working on the sine bar traverse the cross slide and so, through the tapes, roll the spindle to give the correct angular movement to the gear being ground. Rigidity of the complete mechanism is an important feature, which gives accurate lead generation to within 0·0001 in per in of face width.

Indexing is by a pawl and notched disc mechanism, and the lead is controlled by a sine bar, rollers, a slide and steel tapes working on the spindle.



Internal helical gears up to 24 in diameter can be ground on the Orcutt machine, to a high degree of accuracy of form, spacing, lead and surface finish.

CONTROLS

Electro-hydraulic control of the work head movements is effected through Vickers-Detroit valves, with "fail to safety" circuits, which ensure that if any part of the complete sequence should fail, the machine will stop, and cannot be re-started until the fault has been corrected. Interlocks also ensure that the wheel dressing cycle cannot be set in motion until the work head is fully retracted, and conversely that the work head cannot be started while the dressing slide is being used. Two speeds are provided for the dressing cycle, so that wheel dressing for finish grinding can be carried out at a slower rate than when dressing the wheel for a rough grinding operation.

All the push-button controls required for operating the machine are mounted on a panel in the wheel head or on a box adjacent to the work head; they are duplicated on each side of the machine, giving the operator complete control from whichever side he may be working. There is also an inching push-button control at the base of the wheel head which is used to swivel the head to the required lead angle when setting up.

Continuing Companies in the News

five years' lee-way to make up on entering the gas-turbine field after the war. To-day, however, they are achieving considerable success with the Eland propeller turbine, both as a helicopter power plant and as an orthodox airliner engine.

In the diesel engine field they have been notably successful in the development of turbo-blowers and in the Deltic high-speed two-stroke opposed-piston diesel engine, with industrial application as well as for marine propulsion and rail traction. Other post-war activities include rocket engines, ram-jet research, an airframe electrical de-icing system, and the making of precision castings both for their own uses and for other engineering firms.

Irrepressible Jaguar

In his annual statement to shareholders, Sir William Lyons, chairman and managing director of Jaguar Cars, tells the stimulating story of the company's amazing recovery from the major fire of February, 1957, and of continued progress. Trading profits rose from £795,000 to £844,000 and sales were up in all markets. During the year the company exported cars to 84 countries, at a rate of 6 per cent higher than the previous year. Nor are there signs of any decline in demand: the figures for the first quarter of 1958 show an increase of 40 per cent in general exports on the corresponding period of 1957. Shipments to the United States were up by 20 per cent and to Canada by 10 per cent. "The demand for our cars," said Sir William, "continues to grow at a greater rate than our capacity to meet it."

The remarkable results achieved by Jaguar since the war can only be explained by the vigorous promotion of a first-class product. The *Autocar*, quoted by the chairman in his statement, stated last May that "if it were possible to devise a merit table relating performance with comfort and safety with cost, there is little doubt that Jaguar would be at the head of a world survey." The company's performance in western Europe, and particularly in Switzerland, which most car manufacturers regard as the toughest of all markets, is very satisfactory, and they are more than holding their own. Perhaps the greatest compliment one can pay to the company is that after more than five years of strenuous efforts to capture some of the highly profitable markets in which Jaguar operate, all of their competitors have failed utterly to make any real impression.

An Oil Forecast from Belgium

The survey of the market for petroleum products contained in the annual report of Petrofina, the Belgian company, is somewhat more optimistic in the short-term than those of the other oil companies. The company supply oil to European markets and experienced little fall in demand for their products due to the relatively high level of activity in European industry during the second half of last year. Commenting on the fall in profits of most oil companies, the directors of Petrofina say "our own experience has been different and our group's increased sales made up for the lower margins of profit in the last few months of the year." Nonetheless, there has been a marked reduction in the profit margin of the refiners and no sign that this trend is likely to alter very much during the current year, except, perhaps, for the worse.

The most interesting point made by Petrofina is that, in their view, "the oil industry is less susceptible than are other industries to the effects of economic crises." They point out that the gradual deterioration of the economic situation in many countries of the Western world has not stopped the increase in the consumption of oil, "it has only slowed it down." Long-term forecasts lead Petrofina to expect "a considerable increase in the consumption of petroleum products" on the grounds that oil will have to meet the greater part of the new requirements for power in the coming years, "until atomic power can make its contribution." They do not consider that any new factor has appeared to modify the estimate of the date, "still far ahead," when atomic energy will be able to satisfy an appreciable part of the extra needs for power. The scope for a major increase in the consumption of petroleum products in Europe is obvious, since at present hydrocarbons provide 52 per cent of the power requirements of the free world but "while in America the proportion is 68 per cent, it is only 21 per cent in Europe."

The fall in prices leads Petrofina to conclude that all companies in the industry must concentrate their efforts on reducing costs on all sides of their operations, and there should therefore be a new spurt of capital investment in the most modern plant to achieve this. Petrofina's comment on capital expenditure, to the effect that it is not possible to reduce budgets which have already been decided on, to adapt them to new forecasts of consumption or to changes in conditions in financial markets, "except after considerable delay," is a most favourable factor for economic stability in the engineering industry.

British Ropes Pull Hard

The chairman of British Ropes Limited, Mr. Herbert Smith, was able to tell his company's shareholders that sales were maintained in 1957, and trading profits increased (by nearly £200,000 to £2·57 million), despite very difficult trading conditions. He mentioned particularly the intense competition which is being met in overseas markets. In some respects the situation has been worsening in recent months, particularly in the shipping industry which constitutes a most important outlet for the company's products. During the latter part of 1957 demand fell below the normal level and shows little prospect of an early improvement.

British Ropes' overseas activities have increased, particularly in Canada and in South Africa, where their subsidiaries and associated companies have had a prosperous year. In Canada there was a fall in business during the last few months of 1957 and trading in 1958 "commenced at a lower level," but Mr. Smith expressed the hope that a recovery might take place in time to produce satisfactory results for the year. They established a wire-rope factory in Mexico during 1957 and the plant is now in production. Exports to other parts of the world were continued at a high level.

Mr. Herbert Smith commented on the Restrictive Practices Act and suggested that it may be wise "at this particular stage" to suspend the implementation of the Act "until trading conditions become more settled and until it can be seen whether the recession in business is likely to be of long duration." It is all too easy, he pointed out, for price structures to collapse and for conditions to become chaotic. He also advised caution in the approach to the European Free Trade Area, the effects of which he feels are hard to assess.

New Records by Simon Engineering

The two major companies in the Simon Engineering Group, Henry Simon (Holdings) and Simon-Carves, both reported record turnovers and profits for 1957. Each of their respective chairmen, Mr. I. Hey and Mr. R. B. Potter, expressed his confidence in the future and in the ability of his company to continue to expand.

Henry Simon's trading profits amounted to £1·30 million, representing an increase of about £120,000 on the 1956 figure. At the end of the year orders on hand amounted to some £15 million and Mr. Hey anticipated satisfactory results during the current year "in the absence of unforeseen factors." Perhaps the most spectacular advance in the group's business was made by Simon Handling Engineers, who secured a million-dollar contract from the Canadian National Harbours Board for pneumatic grain-discharging plants at Montreal and Quebec and a £2 million contract for specialised handling and weighing equipment for the new Russian tyre factory which is being built by the British consortium of Rustyfa Limited.

Simon-Carves' business continued at a high level and turnover in 1957 rose by more than 10 per cent though trading profits at £1·64 million were only some £10,000 higher than the previous year. Mr. R. B. Potter reported that the present contracts in hand, "though slightly less than in December, 1956, should ensure reasonable prosperity for the next few years, notwithstanding that trading conditions are much more difficult than they were a year ago." He expects profits to be much the same as in 1957. As in the case of Henry Simon Holdings, high interest rates and the intensification of credit restrictions led to the postponement of several major schemes, and to keener competition for the work remaining available. Nonetheless, Mr. Potter was able to make a cautious forecast that "if the recession is controlled we might expect a gradual increase in capital expenditure, especially at home, while cheaper money might encourage potential clients in both nationalised and private industry to review their needs for new plant." In their case the major problem of the next few years will be to make up the shrinkage on the power plant side of their activities by expansion in other fields, such as chemical plant, nuclear power, steelworks and constructional engineering.

Problems in Engines

Two recent statements, one by Rolls-Royce and the other by F. Perkins, illustrate the very wide commercial gap between engines for aircraft and engines for road vehicles. In the case of the former the need—and, one suspects, the tradition—is for highly complex units requiring an immense investment in research and development. During 1957 Rolls-Royce increased their expenditure on these items by over £1 million to £4·3 million, or nearly 5 per cent of the company's turnover. The field of aircraft engines is essentially one for specialists, and the tendency is for the number of manufacturers to drop. Rolls-Royce have, or will have, their power plants in almost 60 per cent of the turbo-jet and turbo-prop airliners on order or delivered in the western hemisphere. Despite the steady fall in the world output of aircraft, the company's turnover continues to increase.

In the field of engines for road vehicles, the picture is a very different one. The units are basically simple, well-known and easy to make, provided the quantities required are sufficient to warrant substantial expenditure on tooling. This has long been the case in the petrol engine field where most vehicle manufacturers make their own. Perkins proved that the same principles could be made to apply to diesel engines and increased output to "car level" proportions, the sales being largely to the manufacturers of vans, lorries and agricultural tractors. The implications of this were clear enough at an early stage in the company's development: as soon as the quantities required were sufficient to warrant tooling up the company's main customers would make their own engines. Tradition played a part quite opposite to that in the aircraft engine field, since car makers were nearly all engine makers first and body builders second.

Perkins' turnover in 1957 fell by one-third, to £14 million and for the first time in 20 years the company made a loss. This was due in part to the fall in export demand, but mainly to competition from their own customers in the United Kingdom. Now Perkins are attempting to break into the car market with a new 1½ litre engine, a unit unlikely to be made by car manufacturers for some years unless demand grows unexpectedly fast. They are also diversifying their output. But new markets for their diesels, particularly North America, are opening up and diesel engine manufacture is, as the chairman says, likely to remain "the company's mainstay."

TALKING TO AMERICANS

What They are Thinking and Where it Leads

The United States of America are thought to be passing through a dramatic phase in their evolution. For this reason, ENGINEERING recently sent one of its deputy editors to America in order to examine current thinking in connection with education, science, engineering, management and business. On the basis of his observations, Mr. E. P. Ward has prepared a detailed report, the first part of which appears below. The first section takes the form of a traveller's tale but serves too as an introduction to the later articles. Following his visit to the Soviet Union last year, Mr. Ward has been able to mark similarities and differences in the two countires and to draw conclusions concerning the two philosophies they represent. Mr. Ward's report "How Good Are Soviet Engineers?" was published in six issues from 13 September to 18 October, 1957, and is also available as a reprint.

I LIKE AMERICANS

ONLY an Englishman would be so arrogant as to believe that he could see the future of a great and varied nation like the United States after a short visit. How easy to be wrong. The first two weeks, the first twenty places, the first two hundred people may no more represent the country than the first man encountered.

The first American I met when I began my journey looked like Khrushchev. He was middle-aged, wore a brown overcoat with a velvet collar and spoke with an accent I later discovered to be Hungarian. He also proved to be a lawyer and associated with Liberace. At London Airport he clearly took me for a fellow American, for he turned to me almost plaintively, almost wringing his hands, and said: "How good to be going, to escape from all these puzzles and dilemmas."

At that point I might have returned to my office and begun my report: "Americans look like Russians, wear Bohemian clothes and speak with European accents. They are law-abiding and usually connected with show-business. They are not fond of travelling and, faced with a strange situation or difficulty, tend to give up in despair."

How wrong, how very wrong, I should have been. I was even wrong about this American, for by chance he sat next to me in the aircraft and proved to be a likeable man of charm and character. No more surely can I judge the future of a nation. Already I have been guilty of identifying the United States with America, a confusion that might elicit the same response from a Canadian or Brazilian as from a Scotsman identified as English. But I hope that by looking at the United States from my own peculiar viewpoint, I may say something that is useful in some way, or at least provocative.

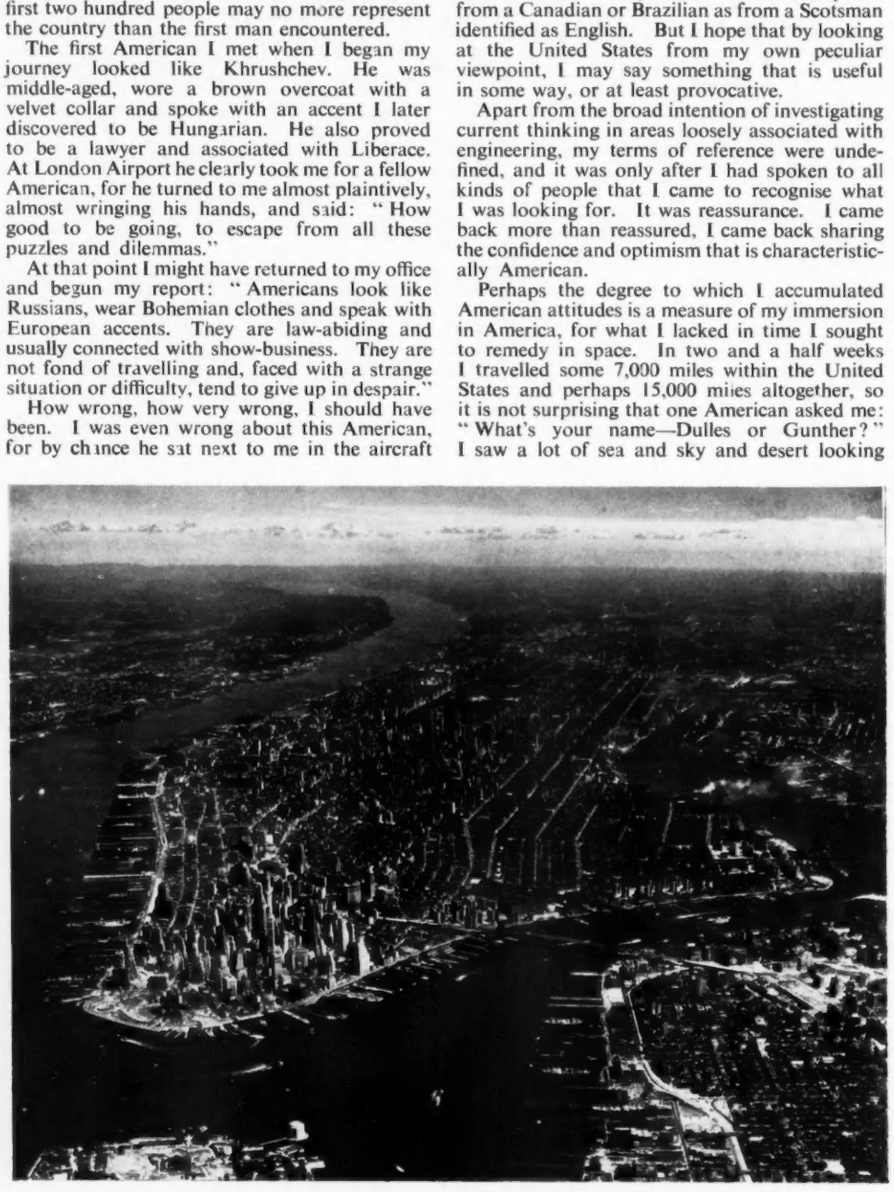
Apart from the broad intention of investigating current thinking in areas loosely associated with engineering, my terms of reference were undefined, and it was only after I had spoken to all kinds of people that I came to recognise what I was looking for. It was reassurance. I came back more than reassured, I came back sharing the confidence and optimism that is characteristically American.

Perhaps the degree to which I accumulated American attitudes is a measure of my immersion in America, for what I lacked in time I sought to remedy in space. In two and a half weeks I travelled some 7,000 miles within the United States and perhaps 15,000 miles altogether, so it is not surprising that one American asked me: "What's your name—Dulles or Gunther?" I saw a lot of sea and sky and desert looking for an answer when I didn't even know the question. The country is so vast, the people so various that a single answer would in any case be absurd; it would be far easier to make a few sour comments on the ubiquity of Main Street and the insincerity of advertising and leave it at that. The Soviet Union, which I visited last year, exhibited, at least to me, a marked unanimity, which made the country simpler to assess; I liked the Russians I met but they tended to agree with one another. Americans proved more elusive. It is therefore not easy to add together all I heard and saw, for each new American was a new attitude, a new way of thinking; to quote one American's views to another was to invite a mild eruption. This is not to say that I found no consistency or common beliefs: I was surprised, for example, to note how closely a man from Wall Street, a man from the AFL-CIO trade union headquarters and a man from the Department of Commerce agreed on the causes of the recession. But there was less agreement on what should be done about it.

Again, we already know so much about America, from films and books and magazines, from American visitors, from our own daily papers. Is it possible to say anything new worth saying? Yet the whole world is looking to see which way America will jump, or more correctly how she will adapt herself to new conditions of leadership. It is not simply that what America thinks to-day we shall think to-morrow—we have experience of many problems that America is only just beginning to discover—but rather that what America does cannot but affect the rest of us. New situations tend to accumulate until a readjustment becomes unavoidable, for the natural inertia of human beings serves to prevent a gradual adaptation. Where do they go from here? is therefore a fair question.

It is also likely to be a question in which science and engineering are involved: America is traditionally a technical nation, and if we accept the idea of a duel or contest between West and East, then it is technical weapons that the challenger has chosen. The areas of interest may thus be defined as education, which conditions the people of to-morrow; research, which determines the hardware of to-morrow; and management, which governs the policies and practices of to-morrow. By talking to Americans working in these areas we may discover what they are thinking and where it leads.

What people are thinking may be a better indication of the future than what they are



Port of New York with Manhattan Island centre.

How the Report is Arranged

In this issue:

I Like Americans, which tells
what the report is about,
why the journey was made,
where I went,
who I saw,
and incidentally, why I like Americans.

In later issues:

America is Going Places Still,
comprising

The Territories, which is mainly concerned with the present and includes two areas:
Way of Life, which takes a quick look at American habits and institutions;
Economic Climate, which is largely about the recession.

The Trails, which discusses some well-worn paths in American thinking and others that have only recently been cut.

The Frontiers, in Education, Research and Management.

Beyond the Frontiers.

actually doing now. I therefore decided that conversation would be more helpful than viewing factories and other premises. In addition, time was limited, and a lot of ideas might come over in talking, whereas I might spend a couple of hours inspecting a plant, and see nothing that I recognised as new. What approach was I to adopt? I could think of questions, but almost always if you can formulate a general question you can foresee the answer; and in any case I wasn't too sure what I wanted to find out. So I decided to present my own outrageous theories and have people snap back at me. Indeed, I had only to say that America expended enormous effort to produce marginal or trivial improvements in well developed products, when they could devote part of this energy to more fruitful enterprises, to receive a series of well aimed arguments, which I shall endeavour to reproduce somewhere in these articles.

RANCHERS TO PSYCHOMETRICISTS

Then I tried to read as many books and magazines as I could; I was flying somewhere almost every evening so I thought there would be ample opportunity. However, I met so many friendly people while travelling, from engineers turned real-estate salesmen and Arizona ranchers to psychometricists and Roman Catholic priests, that most of my reading was completed during sleepless nights. I probably learned more from these people anyway. Still, I skimmed through a lot of magazines and something must have rubbed off. *The Organisation Man*, by William H. Whyte Jr., was on every bookstall, so I bought a copy. There were other books I should have liked to read in addition but didn't find time; *The Secret of American Prosperity*, by Rappard, was one book recommended to me. I also heard a lot of records in drug stores and bars—at least, one record a lot of times—" Dream, dream, dream . . ." was the way it began.

Drug stores, popular songs and Coca-Cola bind the different territories of America together, but from state to state there are many, many differences. I saw as much of the country as I could.

On a Sunday morning I arrived at New York International Airport, Idlewild, after flying the Atlantic by way of Iceland, where headwinds compelled us to make a landing. On being asked by an immigration doctor how I felt, I replied: " Fine, how are you," failing to distinguish between a mere solicitous inquiry and a check for yellow fever. Then a customs official confiscated my orange; presumably in case it was harbouring Colorado beetles or whatever it is that oranges tend to harbour.

Leaving the airport buildings—spotless and colourful like an uninhabited modern schoolroom or a Ben Nicholson design—I passed through doors that opened as soon as they saw me coming, and entered the sleek green-windowed airport bus.

MACHINE-FOR-GRANTED AGE

The long ride to the air terminal was fascinating, most of the distance along a split six-lane freeway with intersections weaving under and over us. We were going fast, but a boy looking about 16 and wearing a vivid red sweater came by on the inside in a smooth looking Dodge travelling even faster. With one hand he held the steering wheel, the other drew a comb idly through his hair. This, I felt, was America, the casual, confident, machine-for-granted age.

Houses are wooden, shops are single-storey, often something remembered from a remote European past; off-beat Dutch façades, Tudor beams and battlements, Colonial styles and clapboard. There is an air of temporariness, of unfinished building. But cars, representing mobility, are costly and refined.

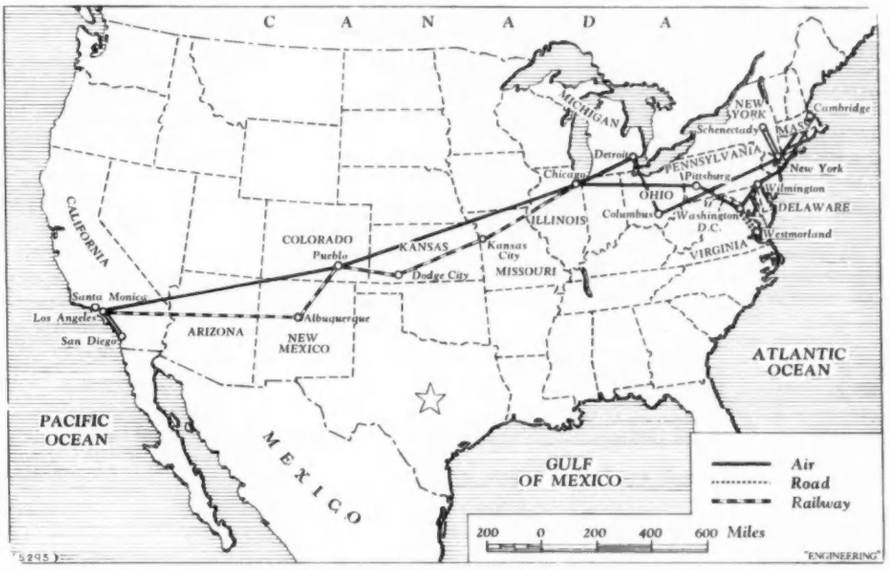
We pass " The Pub " bar and note that " the biggest burgers in the state " are giving way to " the biggest pizzas in the world." I notice that on certain lengths of road we have " speed checked by radar." Then we are approaching a series of gates, rather like the starting gates at horse races, each athwart a lane of the freeway, each guarded by a policeman. Our driver pays a toll fee and we drive into a tunnel beneath the East River, and suddenly emerge in Oz. I crane my neck but cannot see the tops of the buildings: curtain walls, glass, steel and concrete, fifty or a hundred storeys high.

After changing to a cab, yellow with a chequer pattern, I learnt from the driver that the Tigers were coming and that the Dodgers, formerly of Brooklyn had deserted to Los Angeles. Riding in a cab with fins flaring up above the rear wheels made me feel that someone was tailing us, and I kept looking round to see. My hotel was on 42nd Street at Lexington Avenue, and after checking in I took the express elevator, rather than the one for local stops, and levitated without noticing any undue acceleration to the 22nd floor, where in my room I found the water to be hot, cold or iced. I switched on the radio and after hearing " Dream, dream, dream . . .," I was regaled by a chorus singing " You can be sure, sure, sure if it's Westinghouse . . ." I had always looked on Westinghouse as builders of nuclear reactors, heavy electrical plant, subtle electronic devices, and the discovery that they also catered for mere consumers came as a bitter anticlimax. Then from a brief spasm of news (by courtesy of Colgates), I learned that the dark skinned young man who had shown me how to use the electric razor in the airliner—by shaking it till it started—was a member of a Pakistani economic and military mission going to Washington for aid discussions. Finally, before I switched off, I heard a voice advocating fluorination of the city's water; other cities had it, why not New York? Incidentally, one doesn't put one's shoes outside the door at night in American hotels. I was told how in Texas, where they are very rich and prodigal, an Englishman put his shoes outside the door of the hotel room; the chambermaid thought he had finished with them and just threw them away.

The best way to see a city, I thought, was to walk. I remembered a song I had heard in a film: " New York, New York, it's a wonderful town; the Bronx is up and the Battery down." I would walk up past Central Park to the Bronx, and then down back by the East River Drive. New York is really an archipelago, looking from the air like a sprawling Venice. Manhattan Island, the central area, with two tufts of sky-scrapers, is a long narrow island faced on the north east, across the Harlem River, by the Bronx, on the west across the Hudson River by New Jersey, and on the east and south across the East River by the suburbs of Queens and Brooklyn. In Manhattan the long Avenues and most of the subway lines run north-south. Wall Street has its own growth of sky-scrapers downtown; the more spectacular group of towers, including Radio City and the Chrysler and Empire State Buildings, are midtown. Broadway also runs roughly north to south but irresponsibly cuts obliquely across the other thoroughfares. The shorter more numerous streets run across the island. In general the plan is rectilinear.

My walking plan didn't work out, I missed Central Park completely and my feet wore out before I reached the Bronx; the East River Drive was certainly not for pedestrians—after all it did say *drive*. The continual brush of fast moving automobiles made it impossible even to get across, unless maybe you meant a marble one. But I saw a lot of Lexington Avenue and some of Fifth—Saks appropriately selling dresses and Scribners selling books. I also took a walk down Park Avenue where I went into the Waldorf to rest my legs and to watch, within its deep-pile glittering darkness, the smooth elegant deportment of *haute couture*, in the flesh. Afterwards I had a meal of scallops and iced Milwaukee beer in the yellow-lit gloom of a bar in some obscurer street. At this stage I hadn't fully realised that 1, 5, 10 and 20 dollar bills were the same in colour, size and design, except for a variation in the choice of President depicted.

When I had eaten I began to realise the significance of five hours back. I was really



Round the U.S.A. in eighteen days.

Itinerary:

Sunday (27 April) arrival New York

Monday (New York)
- Chase Manhattan Bank (Atomic Energy Division)
- John Diebold (Data Processing Consultant)
- International Business Machines

Tuesday (New York)
- Development and Resources Corporation
- Frank H. Wyman (Financial Consultant)

Wednesday (Schenectady)
- General Electric Company

Thursday (Columbus)
- Battelle Memorial Institute

Friday (Detroit)
- General Motors Technical Center
- Super Chief (Chicago-Kansas City)

Saturday
- Super Chief (Dodge City-Albuquerque)

Sunday
- Arrival Los Angeles
- Flight to San Diego

Monday
- Convair (San Diego)
- Douglas (Santa Monica)

Tuesday
- Westinghouse (Pittsburgh)
- U.S. Steel (Pittsburgh)

Wednesday
- White House (Washington)
- Du Pont (Wilmington)

Thursday (Washington)
- Naval Research Laboratory
- AFL-CIO (trade union headquarters)

Friday (Washington)
- U.S. Atomic Energy Commission Headquarters
- Department of Commerce (Office of Business Administration)

Saturday (Washington)
- Idle

Sunday (Westmoreland)
- John Dos Passos (Novelist)

Monday (Cambridge)
- Harvard University (Faculty of Arts and Science)
- Harvard Business School

Tuesday (Cambridge)
- Massachusetts Institute of Technology
- Arthur D. Little Inc.
- National Research Corporation

Wednesday (New York)
- National Broadcasting Corporation
- Radio Corporation of America
- *New York Times*

Mid-day Wednesday (14 May)
- Departure Queen Elizabeth

Continuing Talking to Americans

tired. But it was worse when I woke up at two in the morning wanting breakfast. You can't change your habits by five hours overnight. The situation continuously deteriorated as I travelled further and further west; eventually I didn't sleep at all, or only in snatches. Nevertheless on the Monday morning I felt up to anything. After rearranging my itinerary with Thomas Cook and Son to fit in with the correspondence that had been waiting for me at the hotel, I went downtown to Pine Street for an interview with Dr. Paul Genachte, Director of the Chase Manhattan Bank's Atomic Energy Division. He set me off on the right foot, for besides being a most pleasant and helpful man, his stimulating remarks on the attitude of American business to the vexed question of public or private atomic power oriented me for later discussions of a more general nature on this central question of American policy—how much Government interference?

YOU MIGHT AS WELL WALK

Mr. John Diebold, the business consultant and specialist in automatic data processing, had kindly invited me to have lunch with him at the Harvard Club. I took the subway from downtown. Fifteen cents buys a metal token which, placed in a slot at the gate, admits you to the platform and allows you to travel any distance. But I got off at the wrong station and had to hire a cab. Never take a cab cross town at mid-day; you might as well walk. But walking is also pretty slow, because it is obligatory to wait at all intersections for the pedestrian traffic signals, which instruct " Don't walk " in red or " Walk " in green as the case may be. " Don't walk " is not a hint to run, and skipping between the open jaws of Cadillacs is just not done.

I was a few minutes late at the Harvard Club, but Mr. Diebold, who works to pretty tight schedules, was quite unperturbed and would not let me apologise. The Harvard Club is gentle and distinguished like a college hall, with portraits of people who might easily be Rutherford or J. J. Thomson on the walls. There I sampled my first Manhattan. When the service was momentarily slow, Mr. Diebold remarked " We use Yale men as waiters, you know." We discussed the effect that computers might have on business and national administration. Curiously, almost the whole dining room was clear of people by 2.15, when they were all presumably back at their jobs. Could this be said of the Athenaeum or Reform?

Mr. Diebold's remarks proved useful in the afternoon, when I visited the IBM World Trade Corporation's offices on United Nations Plaza, opposite the great deep-framed window that is the United Nations building. Mr. Diebold walked part of the way with me and pointed out the immense bank vault behind the huge plate-glass window of the Manufacturers' Trust Company building. " Formerly," he said, " the safe was way underground, and thieves could work at it in peace."

COUNTER CURRENTS

International Business Machines received me with the generous hospitality which became a familiar feature of my journey, only regretting that I had not been able to have lunch with them and that I should not be able to visit their plant at Poughkeepsie. Instead the manager of publicity, Mr. Geoffrey Kean, invited me to have breakfast with him on the morning of my departure from the United States. He and Mr. B. D. Hauser, director of customer relations, enlarged my ideas on the revolution that new methods of communicating and processing information are bringing about and introduced me to the idea of " job extension," a move away from increasing specialisation.

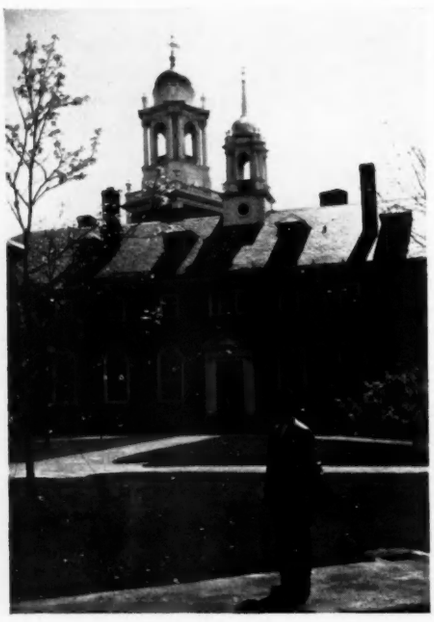
On Tuesday, in the morning, I again took the subway downtown. Though the trains are antiquated and more like underground trams, they get you there very quickly, partly because a straight up and down railway system is easier to operate, and partly because the services are sensibly divided between local and express long-distance trains. First I visited the Development and Resources Corporation, where I met David E. Lillienthal Jr., whose father had carried through the great project which the world came to know as T.V.A. He introduced me to Mr. William L. Voorduin, vice-president and director of engineering of the corporation and formerly chief civil engineer of the Tennessee Valley Authority, who told me how a private corporation set out to help backward countries help themselves. The corporation was in fact an agency for communicating the technical experience of the West to nations whose salvation lay in making the best of all their natural resources—from water power and natural gas to arable land—by means of integrated schemes. In a sense the corporation represented a counter-current in American thinking—the belief that the more resources you control the better you can exploit them.

Before eating I walked about the downtown area. Unlike midtown, the downtown streets are narrow and dark like canyons, for buildings have been built high in order to exact the maximum value from precious land—land which was occupied when streets had little reason to be broad. Occasionally between the towering blocks one comes upon a blackened Gothic church made tiny by its neighbours. In a long bar—" Occupancy by more than 252 persons is dangerous and unlawful "—I ordered a sandwich and buttermilk, having little time and negligible appetite. I was immediately presented with a vast steak generously garnished with salad, French fried potatoes and mushrooms. Not wishing to argue, and finding my appetite had returned, I set about it and discovered eventually a tiny crisp of bread that had been buried beneath the meal. I concluded that the evolution of the sandwich was evidence of a change in American life. When Americans were poor and harrassed they had only had time and money for a simple sandwich at mid-day; as they became more leisured and wealthy the sandwich had grown with them. But I may be wrong.

THE BUSINESS OF AMERICA

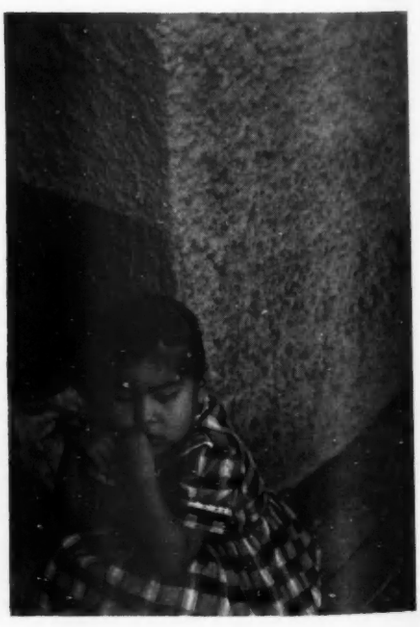
With a loaded stomach I went back to Pine Street, where on the fifty-fifth floor of a high building I met Mr. Frank H. Wyman, a business consultant who most amiably discussed his views on the recession, and pointed out the errors in my naive supposition that Americans were not buying because they already had all they wanted.

Taking the subway, I noticed an advertisement that to my horror advocated spending one's savings—in the national interest. Back in midtown, I found I had an hour before I was due to catch the airport bus so I went up the Empire State Building and was awarded an enamel badge to say I had. A flight and a bus ride took me to Schenectady and on the Wednesday morning I called at the headquarters of the General Electric Company. There Mr. P. J. Garey, manager-administration of International G.E., explained the company's organisation and its attitude to decentralisation and employee shareholding. The company had advanced a long way since John Dos Passos had written " Steinmetz was the most valuable piece of apparatus General Electric had." I was then taken to the company's research laboratory on the Mohawk River and discussed with Dr. Miles J. Martin the way in which research was organised. Following a pleasant lunch, which included a Whisky Sour, I was grilled in a most charming manner by the entire staff of the *General Electric Review*, but got in a few questions of my own.



Harvard University, Cambridge, Massachusetts.

Highest tower: Empire State Building.



Navajo girl in Albuquerque, New Mexico.

Coast walk, Santa Monica, California.

Super Chief about to leave Chicago.

Home of novelist John Dos Passos in Virginia.

That evening, I flew by way of New York, La Guardia, to Columbus, Ohio, and on the Thursday visited the headquarters of the Battelle Memorial Institute, where I enjoyed a most fascinating round-table discussion with Mr. John S. Crout, vice-president of Battelle; Dr. Frank C. Croxton, technical director, chemistry and chemical engineering; and two of their colleagues, ranging from gasoline additives and the organisation of sponsored research to education and diversification.

Detroit was my next destination; Detroit where, if you yourself are out of a job, the recession is a depression. A taxi driver told me how he had been earning a hundred dollars a week at Pfeiffer's Brewery, but when the automen were out of work they didn't drink so much beer, so he had been laid off. His share of the cab was likewise not paying too well, for in normal times a lot of auto-workers travelled by taxi—" the American working man likes his luxury." A newspaper headline announced " Bank Robbers Strike Again "—" It's always like that in hard times," said the cab driver. " The younger man has the hardest time, because the rule is last in first out, and its been going on so long now that the 20-odd weeks during which the payments under the guaranteed wage keep coming, have run out for a lot of people." The driver was glad of his pension from the police department, which he received as a result of being wounded in the course of duty. But I didn't see any breadlines or groups of idle men; Detroit was just a tall town, with shops and people shopping. At the snack counter opposite the General Motors building where I had breakfast on Friday morning—" You are a stranger here but once "—an unshaven man with nowhere to go was using up dimes playing " Dream, dream, dream . . ."

General Motors makes a lot of things besides automobiles, and the Technical Center, which is out of town, is a magnificent arena of diversified research pavilions. A bright metallic dome gives it the aspect of a Moon base.

SUPER CHIEF

From Detroit I flew to Chicago, a cross between Glasgow and Geneva, but taller. There I caught the Super Chief. The Super Chief is a long, thin, articulated, stainless-steel quality hotel on wheels, with a solarium, or sun parlour, and a rose on the table at meal times. On this occasion it was hauled by five locomotives. After I had settled in my compartment the negro attendant brought me a very large brown-paper bag—are people that trainsick? I thought—but it proved to be for my hat, which by this time was beyond the need for care and protection. There was a switch marked " local radio," " popular music," and " classical music "; the last two gave out with Rachmaninov and Johann Strauss, and " local radio "—at this time still Chicago—with " Dream, dream," etc. I went to the dome car.

In the dome car at night it was like being in a space ship—not that I've been in one so often as to know. Sitting comfortably in rotating easy chairs within the raised glass bubble, and travelling, it seemed, among the stars, one could hear the remote insulated rumbling of the rocket motors and occasionally an irregular muffled pounding as we ploughed through a belt of asteroids—or crossed an intersection in the tracks.

There I met a man who measured people's minds. He was a psychometricist and had been to Yale, and countered Mr. Diebold's quote about Yale waiters, by saying that Yale only reckoned Princeton as a rival these days. He said his name was Whitney and I got to like him a lot. A Whitney had endowed Yale, another was United States Ambassador to Britain, a third was first director of the General Electric Research Laboratory; there is even a Mount Whitney in California. He met a famous Whitney once, he said, but he himself was just a stray.

WESTERNS

He didn't think you could put people in categories; it was interesting to call them pykniks or ectomorphs, but it didn't get you anywhere, not yet anyway. His firm regarded each candidate as an individual, but after you'd met a lot of individuals your guess as to whether a particular man would fit a given job was likely to be better than most people's. We talked about " Westerns," about Shane and Wyatt Earp, about gunfighters and " I wouldn't do that if I wz yu " and how the quiet gunman with his " hidden persuader " no doubt had a profound psychological significance and was why Westerns were so popular. We condescended about the Indians and said they were the only ones that kept the treaties—at least that was the line taken by modern Western stories.

We went down to the elegant peep-light bar and had a beer before retiring to our beds. In the night we went through Kansas City and Dodge City, and through Illinois, Missouri and Kansas. During the following day we entered Colorado, passed through New Mexico and into Arizona. We saw prairies, desert, scrub, red mountains, and Indian villages with low rectangular adobe houses, the mud so blending with the background as to make the dwellings scarcely visible. I discovered where all the American cars went; they were dumped in New Mexico. " Our cars are just a load of junk " said Mr. Whitney with characteristic American modesty. Three had been driven into a river so that their hardtops provided a series of stepping stones—or possibly a ford. Suddenly after miles and miles of red earth, a town would rise out of the desert, bright with the familiar marketing colours of Caltex and Coca-Cola.

In Albuquerque the train stopped, and, being a tourist, I bought a colourful Navajo pot for the modest sum of 50 cents. Later I talked with a heating and ventilating engineer on his way to a convention and a chemist on his way back. The chemist told me about Death Valley, the Petrified Forest (there was a fossil tree trunk at Albuquerque) and the California national parks. He said that a party of settlers had been crossing the Sierra Nevada when they had been trapped by winter snows and did not escape until half their number had died and been eaten by the surviving half. It was getting dusk as we fled past a gas storage depot with its vessels painted pastel shades of pink and blue and yellow, like a translucent fairy city which would disappear at dew-fall.

On Sunday morning, after crossing the Arizona and Mojave deserts by night, we left the mountains and soon began to see the palms and orange groves of California, and then the white houses on the outskirts of the most extensive city in the world. At Los Angeles, appreciating the warm sun and blue skies, I went straight from the station to the airport and flew to the naval base of San Diego, passing Mount Palomar on the aircraft's left. In San Diego I was pleasantly entertained by Convair, on the first Monday of my second week, learning something about the frontiers of air and space travel, and in the afternoon flew to Santa Monica to visit the Douglas Aircraft Company. There I heard more about rockets and civil aircraft. In offices at both companies I saw large photographs of nebulae—an indication perhaps of where their ambitions lie.

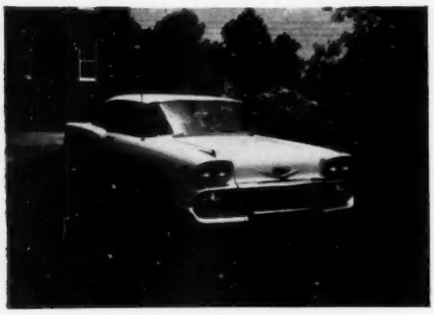
I had until after eleven that evening, so took the opportunity to have a swim in the Pacific and then decided to walk to Los Angeles airport. Fortunately I met an Englishman who took me there by car. Overnight I flew to Pittsburgh, where I visited the Westinghouse Electric Corporation and added to my ideas by a meeting with the vice-president, engineering. Later, at the offices of the United States Steel Corporation another vice-president, this time concerned with administration, talked to me about problems of organisation. This was Tuesday and in the evening I travelled to Washington, hoping to attend the Presidential Press conference usually held on a Wednesday morning.

WHITE HOUSE

At the gates of the White House were two very tall policemen. " Identification? " asked one. I handed him my passport. He studied it. " Well, Ed.," he said, " what's the idea? " Now my name is Edward but I am unfamiliar with its use, so I presumed he was addressing his companion. This led to a mild misunderstanding, but eventually I remembered my letter from Mr. James Hagerty, the President's personal Press secretary, and produced it. I was in. Unfortunately, President Eisenhower, who had appeared on television the previous evening, was resting up and would not be holding his Press conference. I was disappointed, but Mr. Hagerty very generously talked to me for an hour, and what he said helped me understand the present situation in America. In his room I noticed a replica of Dopey standing incongruously by a bust of Nefertiti, and a card on the wall bore the following legend. " One day as I sat musing sad and lonely and without a friend, a voice came to me from out of the gloom saying, ' cheer up, things could be worse.' So I cheered up and sure enough, things got worse! " Recent reports, however, suggest that things are getting better.

At mid-day I set out for Wilmington to visit E. I. du Pont de Nemours and Company. Unfortunately, the changeover to daylight saving time caused an alteration in flying times and the plane itself was late. Watching the many aircraft wheeling on the apron, I realised how complex a problem was flight control in the United States. Complexity, it occurred to me, would surely be one of the factors most likely to affect the future evolution of America.

I was two hours late for my appointment at du Pont, but my host, Mr. John A. Laberee, not at all put out, quickly arranged for me to see



Hired car, Chevrolet Bel Air.

G. M. Technical Center, styling auditorium.

The dark is light enough, San Diego.

two of his colleagues and then took me out to dinner.

The following morning, Thursday, I flew back to Washington to visit the U.S. Naval Research Laboratory, where I met the director and saw the value of carrying on a wide range of different pure and applied research projects in the same establishment. "There's no research so pure it hasn't any progeny," I had been told. In the afternoon I met an economist at the headquarters of the American Federation of Labor and Congress of Industrial Organisations, who gave me a comprehensive account of trade-union views on the recession. The following day I visited the United States Atomic Energy Commission headquarters at Germantown and talked to leaders of the team engaged in thermonuclear and plasma research and to members of the Evaluation Section, Civilian Power Branch, and the Industrial Section, both of the Division of Reactor Development. In the afternoon I visited the Department of Commerce and secured a last authoritative view on the recession from the assistant director of the Office of Business Economics.

SHAD ROE

After an idle Saturday, I hired a car on Sunday morning to drive down into Tidewater, Virginia, where I had an invitation to meet the novelist, Mr. John Dos Passos. The car I hired, a 1958 Chevrolet Bel Air, seemed anything but "a load of junk." Mr. Dos Passos and his family most courteously entertained me to a splendid lunch of shad roe, and we talked about a lot of things and swam in Chesapeake Bay. I had wanted to meet Mr. Dos Passos because his books were about the whole United States, not about Americans in Europe or particular groups of Americans or areas of America, but about the entire complex pattern of his country. His triology *U.S.A.*, though mainly about an age now past, was a standard by which I could measure all my impressions of America.

That evening I flew to Cambridge, Massachusetts, where I spent two days and met the dean and associate dean of engineering and applied physics in Harvard University. In addition I sat in on a class at the Harvard Business School and learnt of the sad decline of Dingle's Dairy, besides talking with members of the faculty. At the Massachusetts Institute of Technology I had a conversation with the Dean of the School of Science. While in Cambridge I also visited two further research organisations, Arthur D. Little, Incorporated, and the National Research Corporation. In the evening of Tuesday I flew back to New York.

During my last morning in the United States I called at the headquarters of the National Broadcasting Corporation and the Radio Corporation of America, where I talked about organisation and decentralisation with the vice-president, engineering services. I also had to clear myself with the income-tax authorities in order to leave the country.

The last comment I recorded before I caught the Queen Elizabeth for England was that of the negro cab driver who drove me to the berth. He was proudly American and couldn't abide the other countries he had been in. America was his country and clearly he had the confidence of feeling accepted by America. His certain and aggressive citizenship lent force to his words. "Green grass," he said, "is just a waste o' ground; put something on it, I say." He seemed to be making a final statement on the American way of life: nature is O.K., but man is here to mess it around, and that's the way it should be.

APOLOGIES TO TEXAS

I had met a lot of people; I met some more on the ship: a rancher oil man from Palm Springs, who represented the tough attitude of America; and a tool manufacturer of New York, who, being an Austrian immigrant, could look on America more disinterestedly than Americans of longer standing. There had been another rancher, from Arizona, who flew with me from Chicago to Pittsburgh, who told me how he had lost all his money in the depression but was now rich again; on the same flight there was an air hostess who declared "I just love to hear you talk," and on the strength of my accent gave me a second cup of coffee. In New York a man saw me looking at a huge modern block of flats and said "they weren't there yesterday." A Government clerk in Washington walked with me half a mile to a tramstop in case I should get lost—then walked back the way he came. There was an electronics engineer who bought me a drink, and a professor of Romance languages who shared his taxi with me and knew more about radar than I did. People asked me why I hadn't been to Texas; I told them I was visiting the United States, maybe I could see some of the other countries in the Western Hemisphere on a second visit. Texas is chipped about its size continually, though some believe the state employs a panel of humourists to make up stories on its behalf.

It's not surprising that I like Americans. They did not in the least resemble the stereotype one sees in cartoons, though I gather that Mr. Osbert Lancaster has found a new one—tall and dreamy with a high crowned hat and quality overcoat. Most of them were rather diffident, modest people, often ready to tell jokes about themselves: like Whitney who gave me a most curious account of his visit to Egypt. For some unknown reason he thought he would be safer if he pretended to be British, so he bought a swagger stick and a pith helmet, but was nevertheless beset with all kinds of proffered services he didn't want. Two unwelcome guides accompanied him up the Great Pyramid and at the top requested a large donation, telling him how dangerous it was climbing down. Contrary to popular belief, Americans are quick to give credit where it's due, even when it comes to winning wars. I was always being told how the British had developed some synthetic fibre, a method of optical tooling, a form of construction for the envelopes of ballistic missiles, electronics, télevision, or the first civil jet airliner. Their capacity for self-parody is enormous. No other nation has a magazine like *Mad*, which strikes ruthlessly at the American and every other way of life—though maybe they're only trying to be funny.

Before I went to America I was told that I should find the Americans stranger, remoter than any other people I had ever met. They're not. They're just more difficult to disentangle. When I look at an American, I am likely to see his German characteristics, say, highlighted, while a German may tend rather to see the Englishness. Americans may be brusque, even to the point of rudeness, but not unfriendly—after all, even the English appreciate the manners of Groucho Marx. I even came to like "All I Have to Do is Dream," and bought the record. People always seemed willing to help; indeed it appears that one product of wealth and leisure is that people have enough energy left over to be nice to you. And the expression I remember hearing most is "No trouble at all."

Indian territory, from the dome car.

Broadway melody, New York.

PUT TO FLIGHT FOR EVER

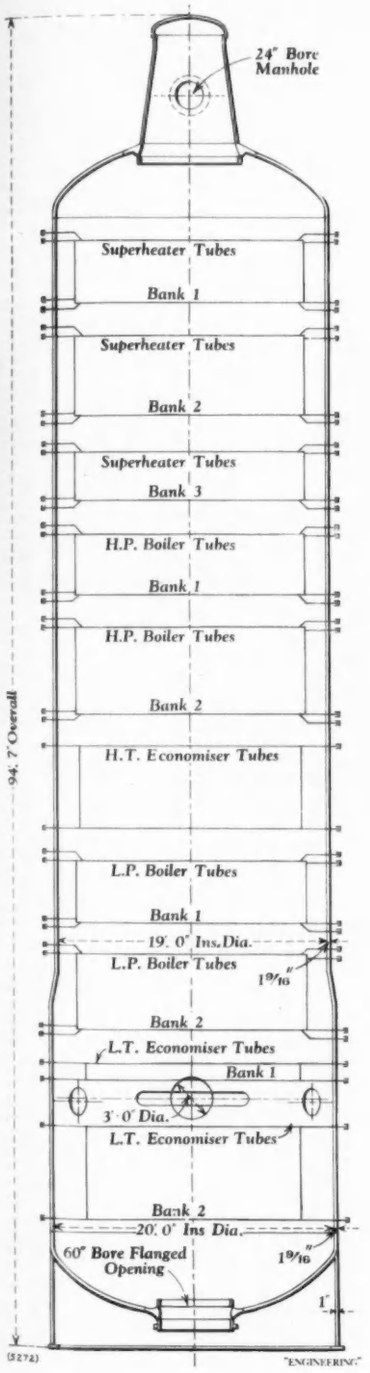
At the end of my journey I may not have been quite as unruffled as Phineas Fogg after he lapped the world in 80 days, but I had learnt something: there was nothing wrong with America that Americans couldn't cure. We in Britain could sympathise more easily with a nation that had come second in the satellite race, had had troubles with its neighbours, and was suffering from a recession. It was perfection that we found so irritating. But there was no reason to be dismayed by these particular imperfections, and once the recession was defeated the old spectre that a free economy would always suffer from cyclic disorders of an unmanageable nature would have been put to flight for ever. In subsequent articles I shall attempt to describe the readjustments that are taking place, the way people are thinking and where these thoughts may lead.

Atomic Review

Pressure Vessels in Manufacture

ATOMIC power stations are massive creations. The principal components—the reactor vessels and heat exchangers—are among the largest precision fabrications that designers, builders and erectors have yet had to handle. The fabrication of steel pressure vessels for heat exchangers and reactor vessels have demanded the highest standards of engineering craftsmanship. In assessing the benefits accruing from the nuclear power programme the stimulus given to the heavy engineering industry by these new demands should not be overlooked.

The first heat exchanger for the Bradwell nuclear power station was recently floated 300 miles down the east coast of Britain from Thornaby-on-Tees where it was fabricated. In the United States a 91 ton reactor vessel has been transported 1,600 miles by rail and river. Some problems of manufacture and transport overcome in these two examples are described below.



Bradwell Heat Exchanger Goes By Sea

On Friday, 16 May, the first heat exchanger for the Bradwell nuclear power station left the Teesdale Iron Works, Thornaby-on-Tees, of Head, Wrightson and Company on its 300 mile sea journey to the station on the Essex coast.

The sizes of heat exchangers have increased since the Calder Hall heat exchangers were built, to cope with the higher thermal power output of nuclear power plant reactors. It was not surprising, therefore, that the transport of a heat exchanger 95 ft in length and 20 ft in diameter, weighing approximately 200 tons, presented a major problem. Furthermore, the production of a heat exchanger vessel, which must satisfy Lloyd's Class I Rules for fusion-welded pressure vessels, calls for a high standard of workmanship and careful inspection at all stages of manufacture and this could only be achieved by completing as much fabrication as possible in the factory.

The Head, Wrightson Company therefore decided to transport the completed vessel or shell by sea—a most convenient way since the works and the power station site are situated right on the coast. If the alternative method of road transport were used, it would have been necessary to move the load piecemeal in 12 or more sections, an operation which might have taken about 22 months to complete and with considerable inconvenience to road traffic. It would also have required a considerable amount of assembly work on site under much more difficult conditions for high quality welding than in the works. By sea, it is expected to be able to deliver one heat exchanger, on an average, every five or six weeks and to complete the whole operation of delivering 12 heat exchangers a distance of 297 miles (by sea) in about 11 months.

The launching of the first heat exchanger from a slipway, in the same way as a ship, was a most impressive sight. The massive cylindrical steel vessel slipped smoothly into the sea and was taken in tow by tugs of the Tees Towing Company, Middlesbrough, who were responsible for the sea transport. Two tugs were used, and a few days later the heat exchanger arrived safely in the river Blackwater, off-shore from the atomic power plant site.

To prevent any damage to the thermal sleeves during towing, timber fenders were bolted in position around each bank and in preparation for the launching, the shell was run on rails to the head of the slipway. Here it was turned through a right-angle on a steel-plate turntable and jacked down to the required angle of decline on the sliding ways. Tallow and soft soap were used on the sliding ways as is the custom when launching a ship. It was launched horizontally with the heavier base section forward. This assisted launching, the large frontal area slowing down the forward motion by water resistance. At sea it was towed the other way round, that is, with the top of the shell to the fore.

The vessel was completely sealed for the journey, rubber sealing rings being used under each thermal sleeve cap. The air inside was maintained at 20 lb per sq. in to assist buoyancy and silica gel was used to avoid condensation which might occur due to temperature changes in the North Sea.

On arrival at the Bradwell site, the vessel was floated into position above a road low loader which had been run down a specially built

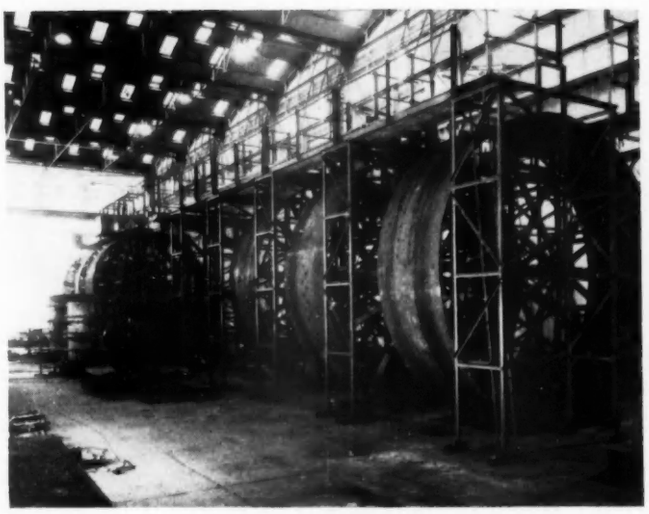


Fig. 1 (left) Diagrammatic cross-section through one of the Bradwell heat exchangers.

Fig. 2 (above) Three of the tiers in the welding gantry.

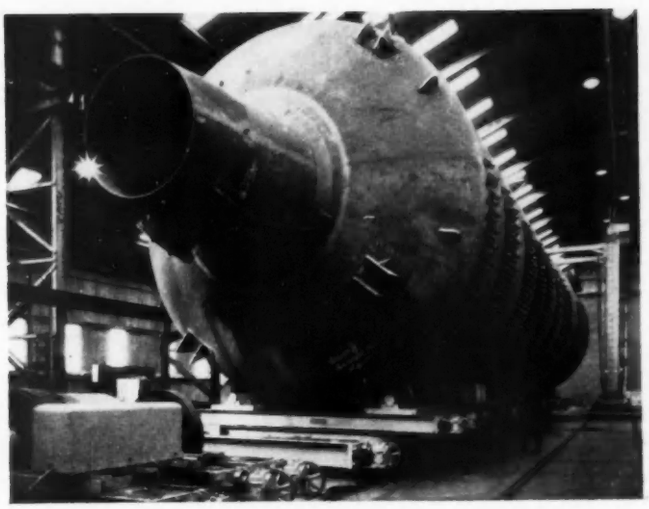


Fig. 3 (right) The completed shell on rollers prior to stress relieving and water testing.

Continuing Atomic Review

Fig. 4 Launching the first heat exchanger from the slipway at Thornaby-on-Tees.

concrete slipway, submerged at high tide. As the tide fell, the vessel settled on the loader which was then hauled ashore by tractors and taken to a place where it could be hoisted by the Goliath crane into its final position.

Details of Heat Exchangers

Each of the two reactors of the Bradwell nuclear power plant will have six heat exchangers, three on each side. In all, the 12 heat exchangers will contain about 200 miles of special finned tubing. Water enters the tubing at the bottom of the exchangers and flows upwards through two separate circuits, one a low-pressure and the other a high-pressure system, extracting heat from the hot carbon dioxide gas which enters at the top after circulating through the reactor, to form superheated steam.

One batch of tubes forms the "economiser" where water is heated up to boiling temperature. From the storage drum containing steam and boiling water the water is pumped to an "evaporator" where more water is evaporated to form steam, and the mixture of steam and water is returned to the storage drum where it passes through cyclones which separate the steam from the water. The dry steam then leaves the drum and enters the final bank which is known as the "superheater." Here the dry steam is further heated and expands to a greater volume, the final temperature being 704° F. The steam conditions from the superheater are as follows:—

	Pressure, lb per sq. in abs.	Temperature, ° F.	Flow rate, lb per h.
Low pressure ..	210	704	87,500
High pressure .	770	704	170,833

The carbon dioxide at a temperature of 734° F enters the boilers at the top and leaves the bottom at a temperature of 350° F, the static pressure being 10 atm or about 150 lb per sq. in abs. with a flow rate of just over 3,000,000 lb per h per exchanger. This is fed by pipeline to the steam turbo-electrical generators.

Construction

The shell of each of the heat exchangers is a vertical pressure vessel fabricated by welding 1 $\frac{5}{16}$ in thick mild steel plate. Over the major portion of the length the sectional diameter is 19 ft, with a 20 ft diameter base. The overall height of each shell is 92 ft 4½ in; the total weight 200 tons.

The plate was supplied by Consett Iron Company to BSS 1501-154, the shell plate being grade C quality (ultimate tensile strength 28 to 32 tons per sq. in, elongation 20 per cent on 8 in gauge length) and the dished ends in grade B quality (ultimate tensile strength 26 to 30 tons per sq. in, elongation 23 per cent). This material was selected because of its suitability for service at temperatures in the region of 700° F, its weldability, notch ductility and freedom from cracking. Before use each plate was tested with an ultrasonic crack detector for any flaws or laminations, then normalised and flattened.

The size of the plates was governed by their position in the shell which was built up in 12 ring sections, four plates forming the circumference of each section. Three of the sections were of 20 ft and 8 of 19 ft diameter, one transition piece from 20 ft to 19 ft diameter, a top and bottom dished end, a bottom skirt plate and a diffuser.

Each individual plate was marked off and a double U butt weld preparation machined on its edges; the plates were then cold rolled to the required curvature. Then the holes for the thermal sleeves were carefully drilled using a special drilling rig. A high degree of accuracy was necessary in this operation to facilitate subsequent fitting of the tube elements on the site of the power station.

The successful construction of these heat exchangers is largely dependent on skilled welding. All the welders had been carefully trained by the firm and it has been estimated that the training has cost about £50 per man. The welding had to comply with Lloyd's Class 1 Rules for fusion-welded pressure vessels, all welds being examined radiographically and finally stressed relieved. Each section or tier was formed by assembling the four plates with the aid of "spiders" to maintain roundness and tack welding. These were then moved to the welding gantry where the internal and external longitudinal welds were made with automatic Lincoln submerged flux arc welding sets. The thermal sleeves were then welded into position and since it was not possible to radiographically examine these welds, a halogen gas test was applied to each sleeve to check for leaks. After the internal fittings had been welded into position, the tiers were ready for assembly. The dished ends consisted of eight segments pressed to shape and welded together by hand in a jig. Reinforcements, outlets and flanges were also welded into position. All the welded joints were X-rayed to ensure soundness.

The ring sections were carried on motorised bogies running on rail tracks. The assembly and welding shops had two sets of track running the full length of the shops, enabling three or four shells to be progressed simultaneously. Each bogie was designed to take four sections of the shell. Rotators on the bogies enabled the section to be slowly rotated at a rate of 18 in per minute while automatic welding was in progress. Welding columns inside the shop carried the welding heads for both internal and external welding.

After the reinforcement rings, outlets, flanges and skirt plate to the bottom dished plate had been welded in position the complete shell was stress relieved by heating to 630° C and allowing the vessel to cool down slowly. For this operation, the outside of the shell was lagged with 8 in thick Stillite insulating mattresses and the temperature raised with internally suspended radiant electric heaters provided by Whessoe Limited.

Final testing consisted of an air pressure test and hydrostatic test at 270 lb per sq. in. On completion of the water test, the inside of the vessel and internal fittings were completely dried and shot blasted to a high degree of cleanliness. The inside was then coated with a brush application of colloidal graphite, silica gel distributed and the boiler sealed up in a watertight condition.

Head, Wrightson and Company is a member of the Nuclear Power Plant Company consortium. Besides the 12 heat exchangers, the company is supplying for the Bradwell power station the shield cooling equipment, the support plates, bearings, restraints and charge pans for the graphite core; the carbon dioxide storage plant; the gas blowdown system; the carbon dioxide pile cap piping; the carbon dioxide interconnecting piping; the pond cooling system and the effluent treatment plant.

APDA Reactor Vessel

Meanwhile on the other side of the Atlantic, by river and rail, a 91 ton steel reactor vessel is being transported a distance of about 1,600 miles to the site of the Enrico Fermi Fast Breeder Reactor (EFFBR) site on Lake Erie, 30 miles south of Detroit, Michigan. This is a 300 MW (thermal) reactor which has been designed by Atomic Power Development Associates, Inc.,

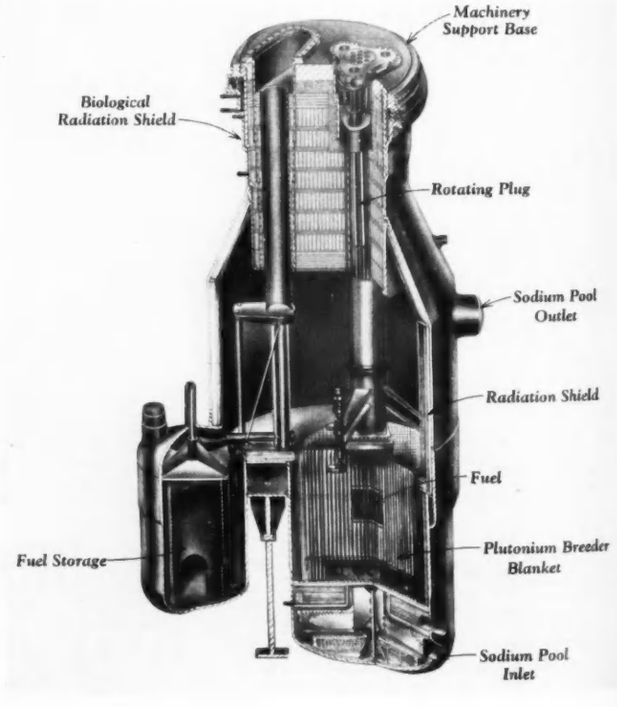


Fig. 5 Sectional view of APDA reactor vessel after installation.

a non-profit membership corporation having as its primary objective the development of atomic power into a commercially practicable means of electric power generation. The Power Reactor Development Company (PRDC), a group of electric utilities and other companies, is financing and building the reactor facility, which it will own and operate. Along with the United States Atomic Energy Commission, the third participant in this project is the Detroit Edison Company, who will build the conventional turbo-generator section of the plant and will operate it on steam purchased from PRDC.

Most of the heat and about a quarter of the new fuel (plutonium) will be produced in the reactor core, which is an assembly of uranium-molybdenum alloy rods or pins (hence the term pin-type fuel elements), that are partially enriched in uranium-235. Surrounding the core is a breeder blanket of alloy rods containing uranium that is depleted in uranium-235; it is here that the remaining three-quarters of the new fuel will be produced from the reactor. Heat is extracted from the reactor core, and blanket by circulating liquid sodium. Further transfer takes place to a secondary sodium system in intermediate heat exchangers and then transferred to water and steam in vertical " once-through " steam generators.

The reactor vessel is designed for 50 lb per sq. in at 1,000° F at the outlet for the upper reactor vessel, and 110 lb per sq. in inlet pressure at 650° F for the lower reactor vessel. Because of these low pressures it was possible to make use of a thin-wall reactor vessel design. In most areas, the vessel wall is heavier than required by technical safety code standards because of the fabrication handling problem associated with a thin-walled vessel of such large diameter.

The vessel (Fig. 5) is a most complex stainless steel pressure vessel. It is made up of four separate cylindrical vessels welded together to form a unit assembly, 37 ft 8 in high. The shape and relative positions of these four major units (which are the lower reactor vessel, the upper reactor vessel, the conical transition section and plug container, and the transfer rotor container) as well as the severe thermal and nuclear radiation conditions expected in service, considerably complicated the design and manufacture.

Description of Vessel

The lower reactor vessel, which has a 9 ft 6 in. diameter, houses the baffling and thermal shielding necessary for protecting the vessel from radiation damage and thermal stresses. It also distributes the inlet coolant flow through the nuclear fuel, the plutonium breeder blanket, the control rods, and the shield. The lower reactor vessel contains the plates which support and locate the 673 fuel elements—which are tubes 8 ft in length and $2\frac{1}{2}$ sq. in—breeder blanket, and reactor control and safety rods.

The upper reactor vessel, which has a 14 ft $6\frac{1}{2}$ in diameter, contains the fuel handling device, the hold-down plate and the eight safety rods. The main sodium coolant discharge is located in this section.

The conical transition section and plug container is a single unit welded to the upper reactor vessel. This section houses and supports the rotating plug, which in turn houses and supports the fuel handling device, the hold-down drive mechanism, as well as the control and safety rod drive mechanisms.

The transfer rotor container houses the transfer rotor, which provides for lateral transfer of fuel and blanket sub-assemblies to a position where they can be removed from the reactor vessel. It also provides the temporary decay storage for irradiated sub-assemblies immediately after removal from the reactor.

The reactor is supported by 12 flex plates which are attached to the bottom of the upper reactor vessel and bolted to foundation plates located below the bottom head of the lower reactor vessel. These flex plates will support a total operating weight of approximately 600 tons.

Welding

It was necessary to use stainless steel for fabrication, a difficult material to weld under the best conditions, because of contact with liquid sodium. Owing to the complex shapes involved, many operations such as fitting, chipping, grinding, welding, polishing, forming and similar work had to be done by hand and depended on the skill of craftsmen. A total of 2,200 ft of welding was required in the construction of the reactor vessel, and 5,900 ft of welding for the shielding, rotating plug and miscellaneous structures. All major welds were radiographed, using various types of X-ray equipment including a 15 million volt betatron, and all welds were tested for flaws by either a dye-penetrant or magnetic particle test. Sometimes welding had to be done in very confined quarters with the aid of mirrors. Closure welds for the lower and upper reactor units, and similar assembly operation, required two months' work on a seven-day basis, including inspection and optical alignment checks. Careful control of the welding process was necessary on vessels of this size to avoid distortion. For major closure welds it was the practice to have four welders working simultaneously and positioned so as to maintain alignment and parallelism of machined surfaces.

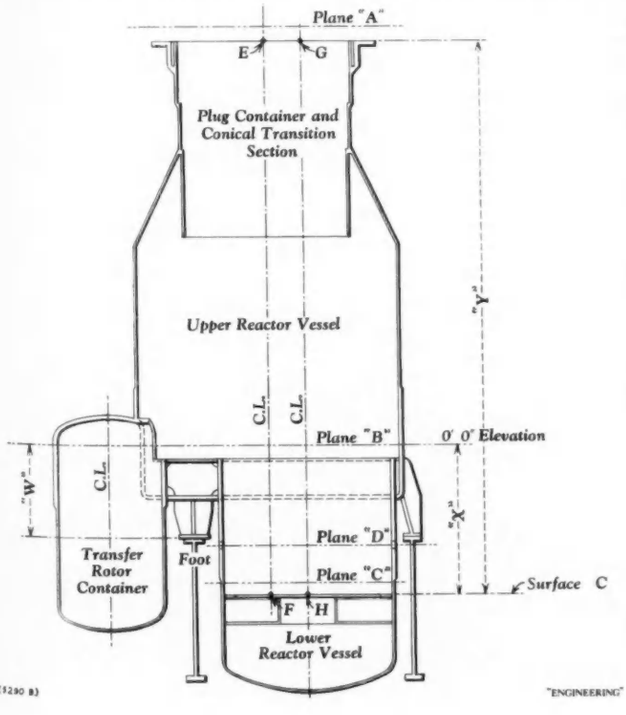


Fig. 6 Optical alignment survey for APDA reactor vessel.

Drilling of Support Plates

Some of the most difficult manufacturing operations involved the support plates for the reactor vessel. These support plates, which are spaced 14 in apart and made from 2 in stainless steel plate, were designed to support and locate fuel and breeder blanket sub-assemblies, control rods and a portion of the lower reactor vessel thermal shield plates. The centre portion carrying the fuel sub-assemblies is a removable square section. There are nearly 1,000 holes in each support plate which are located from two centre datum lines within a tolerance of $\pm$ 0·005 in. Each hole, approximately 2 in in diameter, was machined to within 0·001 in on the diameter.

Optical Alignment Survey

The accuracies required in the assembly and alignment of the APDA vessel would have been very difficult, if not impossible, without the use of optical tooling methods and equipment. For example, dimension " X " in the accompanying Fig. 6 called for $\pm \frac{1}{16}$ in over $96\frac{1}{2}$ in, while dimension " Y " called for $\pm \frac{1}{8}$ in over $355\frac{3}{4}$ in. Final examination of the dimension " X " showed it within $\frac{1}{32}$ in, and dimension " Y " was found to be within $\frac{1}{16}$ in. This was accomplished while maintaining a parallelism of surfaces approximately 10 ft in diameter.

In conducting the optical alignment survey, a series of parallel horizontal planes was established by the use of a tilting level equipped with an optical micrometer and an alignment telescope with a stride level. To start with, the intermediate section of the vessel with the twelve external supports and the transfer rotor container was set up on legs so that the previously established plane " B " was horizontal. Next, the lower vessel was positioned in relation to centre lines and surface " C " levelled. Last, the upper vessel was positioned and the flange levelled in relation to plate " B."

With the previously mentioned optical instruments, planes " A," " B," " C," and " D " were established parallel to each other within two seconds of arc (about 0·001 in in 9 ft). From these established imaginary planes the elevation of some 60 points on the flange was determined in relation to plane " A " and some 28 points on the ledger support ring to plane " C." The distances were obtained with an optical tooling scale which could be easily read to $\pm$ 0·001 in.

The optical alignment check of the upper reactor vessel to the lower reactor vessel with eccentric centres of 24·237 in was accomplished by projecting a vertical line from the centre of the upper reactor vessel (point E) to an optical target in a precision-bored bar in the lower reactor vessel (point F). A vertical line from point " G " to point " H " was projected in a similar manner.

The accuracy of the two projected vertical lines was about two seconds of arc and the optical targets could be read to $\pm$ 0·001 in.

The distance between the horizontal parallel planes were established with a standard 50 ft steel tape supported above plane " A " and hanging plumb inside the vessel. The tape could be easily read to $\pm$ 0·005 in.

Transport Arrangements

Arrangements for transport were planned in September, 1955, immediately after the contract was placed. The first stage was to move the reactor vessel by flat car from the Combustion Engineering Inc. workshops at Chattanooga, Tennessee, to a dock on the Tennessee River, a distance of half a mile, where it was lifted by a 257 ton crane on to a barge. This barge then carried it 928 miles on the Tennessee and Ohio Rivers.

At the Miami Fort Station of the Cincinnati Gas and Electric Company, Columbia Park, Ohio, the reactor vessel was carefully transferred from the barge into the specially designed cradles of a flat car, where it was prepared for its 670 mile rail journey to Lagoona Beach, Michigan. Because of limited clearance on certain sections of the track, average rail speed will be only 10 to 15 m.p.h.

On arrival at Lagoona Beach a 150 ton crane will lift it into position in the 72 ft high gas-tight reactor building at the Enrico Fermi Plant site.

The Human Element

Communications and Scientists

The inability of scientists and engineers to express themselves in a language intelligible to the layman is an inexhaustible subject of boardroom talk. Much of it is unnecessarily critical. Nonetheless there exists a real problem of communication between the research man and his board in most companies. This has been the subject of a survey by the Laboratory Apparatus and Optical Sections' Public Information Committee of the Scientific Apparatus Makers Association of Chicago, Illinois. The title of their report is *Results of a Nationwide Study Undertaken as a Public Service*—which is itself wide open to the type of criticism being discussed. Nevertheless the report gives a wealth of information on the way in which laboratory staff communicate with top management, and on how far they succeed in making themselves understood.

One of the main conclusions is that laboratory reports could be substantially improved, " particularly in the direction of more meaningful interpretation of research findings from management viewpoint." Only one in seven of the top executives interviewed found laboratory reports satisfactory. Apart from the need for more communication and for an improvement in the quality of the report writing, the three most important hints to scientists were to make their conclusions more meaningful; to put more stress on the far reaching implications of their results; and to pay more attention to the dollar and marketing value of their findings.

Meeting the Foreman

Conscious, organised efforts to preserve and even improve the position of the foreman in industry are not very thick on the ground. They are vitally important nevertheless. One such is the Foremen's Club run by Remington Rand Limited at each of its factories. The idea has been developed from monthly regular meetings started by the management some five years ago to keep foremen in touch with the company's activities.

The meetings are now held once a month during working hours and are usually followed by an informal party the same evening. The managing director and top management are honorary members and come to both the daytime sessions and the evening parties. The managing director visits each factory once a month and includes these functions in his itinerary. In this way the foremen have become an active chain of communication between management and the workers on the shop floor. It is an interesting example of the foreman being built up as a channel and not bypassed by management.

The scheme has also produced a number of useful ideas on production methods because it has made the foremen cost-conscious and helped to give them a sense of importance in running their own sections. They have been shown that they matter in the system, and increased interest in their work has been the result.

Miners Show Caution

The miners are obviously disappointed that their wage claim has been turned down by the arbitration tribunal. They lost their demand for a 10*s*. a week increase in pay for a 40-hour week. On the other hand they did not come away entirely empty handed. The tribunal agreed to the idea of a sick pay scheme. The amount at present is not much but the principle has been established for the future. Also the standard working week for coke workers has been reduced from 44 to 42 hours.

The National Union of Mineworkers has expressed disappointment about the award but has accepted it in accordance with its agreement with the National Coal Board. There are signs however that an even bigger claim will come up at the annual national conference in July and that there will be pressure at the same time to scrap the arbitration agreement.

Nevertheless, behind the brave words there is an acute appreciation that the industry is passing through difficult times: coal stocks are rising still and the labour force is falling. Coal is in fact at the moment a declining industry, though this is not likely to continue indefinitely. The fact that wage increases are difficult to negotiate in industries which are not making profits and are being forced to contract seems to be making some headway among the unions.

Attracting Young Civils

Many universities and technical colleges are finding that classes for would-be civil engineers are smaller than those for other sections of the profession. To some extent this is no more than a reflection of the comparative memberships of the three major institutions; all three are expanding steadily in their graduate and student sections and the universities are generally reporting that a higher class of student is coming forward for engineering than hitherto. Even so there is an urgent need to attract good entrants, particularly to civil engineering.

The Civil Engineering Scholarship Trust, formed recently by the Institution of Civil Engineers, the Association of Consulting Engineers and the Federation of Civil Engineering Contractors, have published additional details concerning a scholarship scheme described in an earlier issue of this journal (p. 67, 17 January). Up to 12 scholarships in civil engineering, worth between £300 and £400 per annum for three years, should be available for the coming academic year and a larger number in subsequent years.

The scholarships are designed to help boys who are unable " to secure the full benefit of Government and Local Education Authority scholarships because of the operation of the means test applicable to such scholarships." Applicants must therefore produce evidence that they have the necessary academic qualifications and must also show that the financial circumstances of their parents are such that they could not benefit sufficiently from State or other awards to be able to attend a university or other institution of their choice. This is a novel approach, with obvious appeal to the professional classes.

Hard Times for Union Bosses

The difficulties experienced by Mr. Cousins in his tilt against Government policy are small by comparison with those of his American colleague, Mr. Walter Reuther, in his attempt to force the motor companies to accept a contract they dislike. Mr. Reuther succeeded two years ago in getting accepted the principle of the guaranteed annual wage and of the automatic wage increase based on productivity improvements or cost of living clauses to protect purchasing power. Now he wants to improve the terms within this framework—e.g., a higher percentage wage rise, better unemployment allowances and other " fringe " benefits—and to introduce a new principle of " excess profits distribution."

Under Reuther's scheme, already rejected by all major companies, all profits earned above 10 per cent on net capital (before tax) would be shared between shareholders and executives (50 per cent), wage and salary earners (25 per cent) and the car buyers themselves who would get the remaining 25 per cent in the form of a year-end consumer price rebate. The employers rejected this scheme out of hand on the grounds that it is the management's prerogative to handle a company's profit distribution policy. There is a strong dislike for permanent commitments of this type, which tend to make an inflexible industry even more inflexible. It is also doubtful if such a distribution policy would leave enough margin for ploughing back earnings to ensure growth.

Mr. Reuther's main difficulty lies in the current recession in the United States which has been felt particularly in the motor industry. General Motors have offered a renewal of the existing contract for two years and will accept nothing else. With some 400,000 members of his union unemployed, Mr. Reuther is hardly in a position to call a strike. Like Mr. Cousins, he is fighting to maintain his own personal prestige in what looks like a losing battle.

Seconds Out

It is not every day that the Transport and General Workers' Union and the entertainment industry are faced with the prospect of a deal. Yet such is one of the manifestations of enlightened self-interest. Mr. Jack Solomons, the boxing promoter, offered Mr. Frank Cousins 5,000 free tickets for the British heavyweight title fight last Tuesday if the bus strike was settled beforehand.

Mr. Solomon's offer apparently had no influence what so ever and he did not have to keep his promise, but the idea has it appeal to the student of human behaviour. Mr. Cousins should be flattered. He may not be able to make the Prime Minister wilt or London's public capitulate but he can force Mr. Solomons to try to take out an insurance policy with his union. There are plenty of people both within the trade union movement and outside it who are prepared to tell Mr. Cousins that he has overplayed his hand in the London bus strike but he has the consolation that he has brought troubled nights to the boxing promoters. If Mr. Cousins remains adamant, heavyweight boxers as well as London busmen are faced with lean times.

Bus Negotiations

By last weekend it had become apparent that Mr. Cousins had received little encouragement from the Trades Union Congress to call out any more workers affiliated to the Transport and General Workers Union in a sympathetic strike to the London busmen. The cool reception given by the NUR earlier in the week to support other than inexpensive expressions of workers' solidarity was followed up at the TUC meeting by similar lukewarm gestures by other union leaders. The unions do not relish supporting to extremes men who have manoeuvred themselves into an inflexible position.

Coolness from the movement in general owed something to the idea that Mr. Cousins has played the game of negotiation just a bit too cleverly, and, at the end of last week, just a bit too greedily. The offer of the LTE after the railway settlement to bring forward a review of the wages of those busmen not offered an increase already (and turned down) was a major capitulation to the union's point of view, but Mr. Cousins wanted the gist of that review published in advance. To get that extra bit he was prepared to play tough last week and thereby inconvenience both the public and other workers. This last was clearly the sticking point for other union bosses who thought he had gone just a bit too far. This was the atmosphere when negotiations opened over the weekend.

After negotiations had broken down (on Sunday) the busmen's delegates were consulted and they voted in favour of continuing the strike. Whether or not Mr. Cousins will get the support he is canvassing remains uncertain. On the balance, it seems unlikely.

AUTHORITARIAN BARRIERS TO COMMUNICATION

By Z. M. T. Tarkowski, B.SC.

In a previous article a build-up of embarrassment or irritation in a face-to-face contact was discussed in terms of positive feed-back loops. Subsequently, instinctive reactions in various situations were described and the effects of anxiety considered. The present article shows the role of these various mechanisms in the establishment of a barrier between people at different levels of authority.

There are many men who act in different situations as though they were different people. When confronted with a person senior to themselves they may be submissive and self-effacing; towards those lower in rank they may be domineering and aggressive, or perhaps distant and aloof. Extreme examples of this type of character can be found in organisations formed in a totalitarian fashion. Although we may disapprove of this type of behaviour on principle, most of us display it to some extent on occasion.

Ideally it should be possible for one always to be sincere, spontaneous and easy, to treat everyone with due respect, and wherever necessary to comply or to be firm. Sometimes one may be obliged to preserve distance or to be aggressive.

The achievement, however, of a suitable blend of these attitudes and the ability to change easily from one of them to another is a rare feat which few people can claim to their credit. Ordinarily, in the sort of person we have been describing, called the *authoritarian personality*, one of these approaches becomes "switched on" under certain external conditions, independently of whether it is appropriate or not. Most people do not stop to think, and act, however unreasonably, as the situation prompts them.

The *authoritarian personality* is only one example of a phenomenon which has been called *psychic fragmentation*. There are many others. For instance, many people behave completely differently in the presence of women and in the presence of men. Most people adopt different attitudes often without being aware of it when faced with members of various social groups.

A person whose behaviour is fragmented has to keep his life in separate compartments. His friends fall into several distinct groups and have to be kept apart from his family and from his business acquaintances. It is important to him that the members of these groups should never meet, since to each group he is almost entirely a different person. The desire to keep social life in watertight compartments may be fully deliberate, but in many circumstances the *compartmentalisation* occurs quite unwittingly.

The form of *fragmentation* described here, that is, the *authoritarian personality*, is a great obstacle to the efficient flow of communication within an organisation. A typically authoritarian man will hardly ever presume to offer advice to his superiors, to disagree with them, or, indeed, to be frank; he will find it difficult to convey to them any unwelcome news, and he will accept instructions even if he considers them to be unreasonable.

If the main element in his treatment of subordinates is aggression, he will reprimand them but almost never praise or criticise constructively. If his main tendency is to preserve distance, he will neither praise nor reprimand. In both instances, his behaviour will create stress.

Similarly, he will hardly ever take his subordinates into his confidence. He will not dare to ask their advice, feeling that this would be damaging to his authority. He will not encourage or easily accept criticisms or suggestions from them, nor keep them well informed; and they will find it difficult, in turn, to pass on to *him* any displeasing information.

In a group organised on an authoritarian principle, people of different ranks do not feel comfortable with each other. The social segregation serves both to preserve the distance and to provide periods of rest from the tension existing between various levels of the hierarchy.

In the past when the general standard of education was much lower, and the relationship between various levels of authority much more ruthless, people of an authoritarian character were indispensable to the maintenance of discipline and the integrity and even existence of the whole social order.

To-day, in the conditions of full employment and of greater interest in the work to be done, the authoritarian traits of a person are a hindrance to the full development of his potentialities as a manager. These characteristics are also an obstacle in the way of modern, more efficient, methods of management. This is easily seen if we only consider how important it is, at all levels of management, to be well informed, even if the information happens to be unpleasant. Also it is becoming increasingly necessary to consider all the possible difficulties and objections before a plan is put into operation, as otherwise great financial loss can be incurred. Thus, a free discussion and exchange of opinion is essential, and to this fragmentation and authoritarian attitudes constitute a blockage.

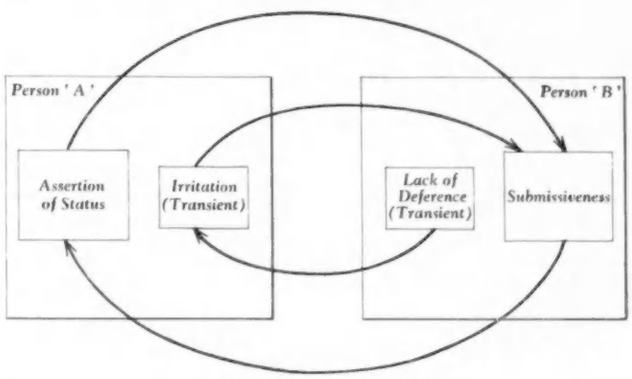
THEORETICAL DISCUSSION

To summarise, a senior man of authoritarian character usually imposes the authoritarian structure on the part of the organisation under his control. A free and easy person not maintaining the administrative distances and endowed with a spontaneous facility of communication both upwards and downwards finds this atmosphere uncongenial, feels frustrated and either moves out or the quality of his work is seriously affected. Similarly, a person of strongly developed authoritarian characteristics does not fit in well in a group where the administrative stratification is not pronounced. Finally, the structure when imposed from above fosters and develops authoritarian character traits in all employees, to a greater or lesser extent, and when a change of attitude is required a long and arduous process of retraining may be needed.

One of the outstanding features of the authoritarian character is *irritation* caused by apparent lack of deference or the free expression of opinion, whether in the form of criticisms or suggestions. The mechanism of *irritability* and the way it affects face-to-face communication has been discussed earlier.[1] Suppose two people, *A* and *B*, *B* being subordinate to *A*, are engaged in conversation. A remark by *B* which appears to *A* to indicate lack of deference or unwanted familiarity will irritate *A* and cause subtle changes in his facial expression and tone of voice. If *B*, similarly to *A*, possesses authoritarian characteristics, he will react, automatically and immediately, by becoming submissive and dropping the line he was pursuing. Thus, the build-up of irritation, due to a self-amplifying process described before[1] will be avoided. On the other hand, *B*'s reaction of submissiveness whenever *A*, for example, slightly raises his voice, will induce in *A* an increasing readiness to resort to this expedient, quite automatically and often unconsciously. In this way a natural hierarchical order of "precedence" is established. Needless to say, the more often a subordinate, *B*, reacts submissively, the more frequently his superior, *A*, is likely to act over his head, to override his decisions or to give him unfair and unreasonable assignments or instructions. In the circumstances the subordinate finds it progressively more difficult to defend himself and to resist his own tendency to be submissive.

At the same time *B*'s increasing dissatisfaction and pent-up hostility will result in a need to dominate and to attack. This increasing need to express aggression cannot be satisfied with respect to *A*, that is, the superior who is its cause, since *A*'s presence by virtue of his being senior and possibly as a result of his manner and behaviour always makes *B*, his subordinate, compliant. Thus, although the hostility continues to build up, *A*'s presence causes its suppression. This means that its expression becomes progressively more easily evoked when the inhibiting factor, *A*'s presence, is not operative. The slightest sign of disagreement or lack of deference on the part of *C*, who is subordinate to *B*, will be sufficient, therefore, to release aggressive behaviour. In this way another authoritarian barrier is established. The pattern is bound to spread downwards by a mechanism similar to what is known as *pecking order* in animals.

Status may be asserted by a domineering attitude or by aloofness.



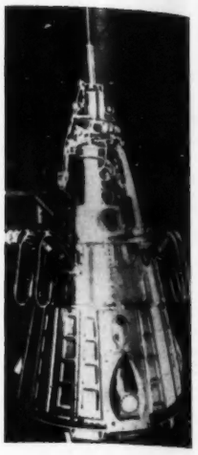
Setting up an Authoritarian Barrier

The fact that submissive or domineering behaviour sequence is automatically released in a given situation relates in a very interesting way to the experimental work of Tinbergen on animal behaviour, which was mentioned earlier.[2] It was found, for example, that various birds and fish attack or escape depending on whether they are on their own territory or not. Thus, a male stickleback will attack, during the mating season, a red object if on his own ground and will escape from it elsewhere. This is connected with the fact that the males of the species acquire red colouring underneath during the mating season. When two males are placed in separate test-tubes and held over the territory of one of them, the "owner" adopts a *fighting posture* and tries to attack, through the glass, the "intruder." The "intruder," in his test-tube, is, trying to flee. On the test-tubes being transferred to the territory of the male who was the "intruder," the roles are reversed instantaneously. It is important to note that any red object will release this reaction of *fight or flight*, whereas a completely realistic model of a male without colouring (as he appears outside the mating period) will have no effect. Robins react in a

Research and Development

ORBITING LABORATORY *Space to Spare in Sputnik Three*

By Kenneth W. Gatland, Vice-Chairman of the British Interplanetary Society



Whether it was the French crisis or merely that satellites are no longer considered headline news, the launching on 15 May of a third Sputnik—this time a heavyweight of 1 ton 6 cwt—did not occasion the amount of publicity one would normally have expected. It was, nevertheless, a formidable achievement.

Looking back over the past few months, it is indeed hard to believe that, following the successful orbiting of Sputnik 1 on 4 October, those of us who were attending the Astronautical Congress in Barcelona had suggested to Russian delegates that "possibly a decimal point had slipped" and the true weight of their satellite, as given by *Tass*, might be 8·36 kg instead of 83·6 kg (184 lb). After all, we had been expecting the first satellite to be America's Vanguard, and although that had approximately the same diameter as Sputnik 1, its estimated gross weight was only 21·5 lb.

Since that time, we have learnt a good deal about Soviet satellite techniques and have become reconciled to the fact that the payload factor—which Western studies had tried so hard to reduce to the absolute minimum to make satellites practical in the economic sense—was of little concern to the Russians. Indeed, from photographs received of Soviet satellite equipment, it is clear that most, if not all, of their research apparatus is standard laboratory equipment.

Sputnik 3, unlike its dog-carrying predecessor, does not remain attached to its carrier rocket. At first, this—together with its great weight and size—appeared to suggest that the Russians might be attempting recovery and that perhaps another animal had been incorporated. Some credence to this suggestion appeared to arise from the construction of the base end of the satellite, which had all the appearance of being a pressurised chamber of pressed-steel "waffle" type construction—perhaps a prototype which, in some later project, might even carry a man. The dimensions, 11 ft 8 in high with a base diameter of 5 ft 8 in, clearly suggested that Soviet scientists were rapidly approaching the stage when an experiment of this kind might be possible; and this theory was made to look even more attractive when, on Sunday, 18 May, the Moscow newspaper *Pravda* published a diagram of the new satellite which, though it enumerated all the instruments, made no mention of the large "waffle" clad container at the base.

Professor L. Sedov, speaking on Moscow Radio on the day of the launching, confirmed that no human being was in Sputnik 3. But a man could easily be carried in a satellite of this size, he said. Nevertheless, it was far too early to talk of sending man into space in a satellite. Many biological problems remain to be solved, and there was the major problem of preserving the satellite and bringing it safely back to earth.

The declared aim of the launching was for "scientific research in the upper layers of the atmosphere and in cosmic space as part of the I. G. Y. programme," and what surprised Western observers most was the confidence the Russians must have in their ability to orbit such heavy vehicles, rather than launch a number of small satellites equipped for different research tasks.

As it is, Sputnik 3 is a completely outfitted research laboratory capable of dealing with nine major research tasks. Apparatus is carried for measuring pressure and composition of the atmosphere, the concentration of positive ions, the intensity of gravity, the earth's magnetic field, micro-meteorites, and the intensity of different types of radiation. Cosmic ray studies appear particularly well catered for in the satellite. According to the Russian news agency, "The temperature régime essential for the normal working of the satellite's equipment is ensured by a system of thermal controls which alter, with the aid of special devices, the coefficients of radiation and reflection of the surfaces." Thermometers have been included to measure internal and external temperatures. The scientific and radio telemetering equipment in the satellite is controlled by a programming device, which allows data to be transmitted in a prearranged sequence to ground receiving stations.

In addition to chemical batteries, the satellite carries solar batteries which produce electrical energy directly from sunlight, like the American Vanguard test-satellite ("New Satellites in Orbit," ENGRG., p. 462, 11 April, '58). The total weight of apparatus and radio equipment is given as 2,133 lb.

The radio transmitter emits continuous wave signals at 20·005 Mc/s (about 15 metres) with a duration of 150 to 300 milliseconds. This frequency, used by all three of the Russian satellites, is not the internationally agreed one of 108 Mc/s adopted for American satellites but, nevertheless, is better for obtaining information about the radio-reflecting layers of the ionosphere and has permitted much useful research in Britain. Although radio stations throughout the world can readily pick up the signals and use them to track the satellite, only Soviet receiving stations can interpret the results.

The orbit of Sputnik 3 is essentially the same as that of the two previous Russian satellites. Launching was made at an angle of 65° to the equator and *Tass* reported that the apogee (maximum distance) was approximately 1,170 miles and that the vehicle was completing one revolution of the earth every 106 minutes. The perigee has since been estimated at about 150 miles, which suggests a lifetime of about six months.

On the opposite page is reproduced a drawing which the writer has prepared comparing the Russian and American satellites. This is not to belittle the American achievements for size alone is no criterion of a successful satellite. The

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very similar fashion.

These peculiarities of animal behaviour can be understood in computer engineering terms if we assume the existence of some form of *gating units* in the nervous system. Their functioning is such that the simultaneous arrival of the signals "*red*" and "*own*" at the input of the gate will result in the output signal "*fight*" and, similarly, the combination of "*red*" and "*foreign*" in the input channels will lead to "*flight*" in the output. A similar mechanism will explain the existence of a *pecking order*, that is, an order of precedence, in a group of animals and this closely resembles the human situation described earlier in this article.

As mentioned before[2], the three sub-routines, *compliance*, *detachment* and *aggression* come into operation in a variety of ways. In unusually well-balanced people they appear when most appropriate in the circumstances. In those who are visibly unstable, the change-over may be sudden and to an untrained observer wholly unpredictable, although some complex regularities may exist. There are many cases of people in whom these sub-routines alternate at regular intervals in some cyclic order, and others in whom they are clearly evoked in a well-defined manner by specific events, for instance, successes or set-backs. The authoritarian personality belongs to a wider class of individuals in whom a given sub-routine is very clearly, automatically and unambiguously evoked by some specific features of the external situation (e.g., the presence of someone in authority, the presence of someone of lower rank, etc.), in a manner similar to the "fight" or "flight" reactions in sticklebacks. It is this type of person to whom the term *psychic fragmentation* applies.

Thus, in a state of stress, except when it becomes unendurable, the behaviour of authoritarian people becomes more stereotyped and more easily predictable. They lose their individuality and become to a large extent standard units conveniently fitting into the framework of the administrative machinery. An organisation built on this principle, however, is inflexible and cannot adapt itself to change.

APPENDIX

The idea of *psychic fragmentation* as applied to ordinary everyday human behaviour seems to be due to Strecker[3] who referred to it as "*segregation*." It has been further elaborated by Karen Horney, to whose works reference was made earlier[1, 2] under the name of "*compartmentalisation*."

The concept of the *authoritarian personality* seems to have been first introduced by Erich Fromm[4] who later used it to explain some of the social and political phenomena of our time.[5] The notion led to a great deal of experimental work in social psychology,[6, 7] some of which gave rise to various controversies[8] and was criticised on the grounds of both scientific method and political bias.

More particularly, the contention of the earlier writers that democratic leadership is, under any circumstances, conducive to greater productivity than authoritarian leadership, seems to have been shown conclusively to have been wrong. Sanford's studies[9, 10] indicate that *authoritarian* people do not work well under *egalitarian* leadership and vice versa. Moreover, there is a certain amount of evidence that both types of attitude are engendered and reinforced by prolonged environmental pressures, as against the view that they are personality characteristics either constitutionally determined or firmly established by the experiences of early childhood.

Examples of complex and automatic determination of behaviour in sticklebacks and other vertebrates are given by Tinbergen in *Social Behaviour in Animals*[11] and in his other works referred to earlier.[2] A full discussion of the phenomenon of *social dominance* or "*pecking order*" and its function in the structure of animal communities is given by Allee[12] and further reference to original work in this field will be found in his book.

An excellent description of the function of *gating elements* in automatic digital calculators and of various gating circuits is given by Booth and Booth[13] in their chapter on *Gates*.

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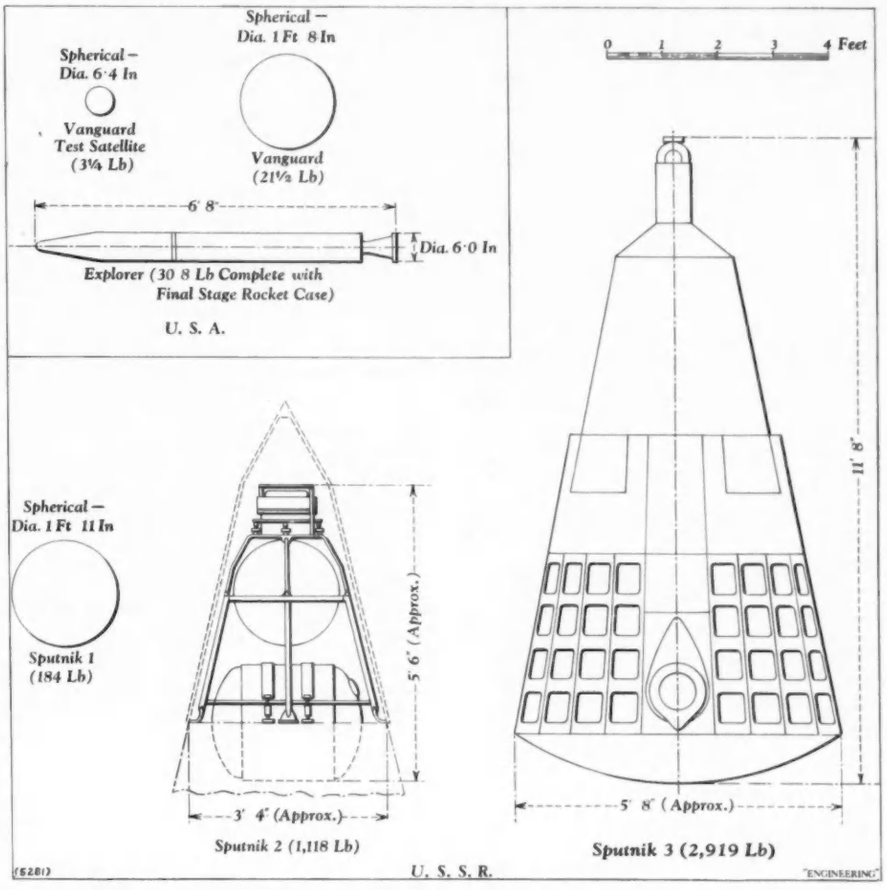
development of the Vanguard test-satellite of only 3¼ lb and the Explorer satellites carrying 11 lb of research instruments and radio gear, has shown that remarkable things can be accomplished with very small payloads. The secret, of course, is in the use of miniaturised components, an art at which the Americans are particularly adept—transistors replace vacuum tubes; printed circuits replace conventional wired circuits; and solar batteries of exceptionally light weight replace dry-cell and wet-cell batteries. Thus, to some extent, the Americans have succeeded in offsetting the Russian possession of heavyweight satellites by developing minimum weight equipment and are achieving significant results with apparatus which, in some cases, weighs less than a portable radio. Nevertheless, the Russian ability to orbit a satellite of 26 cwt —which appears to be beyond the capability of any existing rocket in the United States—must give them a clear advantage in the race to develop a man-carrying satellite.

Russia's satellite experiments will be of particular value in checking the results obtained with Explorer, when the intensity of radiation (cosmic or solar X-rays?) choked Geiger counters in the region of 1,000 miles above the earth; they should also be valuable in discovering any possible influence on this radiation of the earth's magnetic field.

Concerning the launching vehicle itself, speculation is rife over the precise nature of the rocket and its staging. The Russians, of course, are not talking about this aspect of their achievement, although Professor E. Federov has stated categorically that Sputnik 3 was launched with "customary chemical fuels." One is therefore forced to the conclusion that "brute force" techniques are responsible for Russia's success in this field. Major General John B. Medaris, Chief of the U.S. Army's ballistic missile programme, has estimated that the thrust of the initial booster stage of Sputnik 3 must have exceeded 200 tons—more than either the Atlas or Titan I.C.B.M. Some idea of the size of the *final* stage, which is also orbiting the earth, can be gauged from the fact that the base diameter of the satellite actually exceeds the diameter of the German V-2 rocket (5 ft 6 in).

What the next stage of Soviet space-research will be is, of course, a matter for conjecture. Recovery of a satellite package is one obvious possibility, allied with further animal experiments to determine the biological effects of cosmic radiation. The other project of interest to the Russians is a high-speed satellite designed to travel along a "boomerang orbit" which carries it out as far as the Moon. At the Astronautical Congress last year, V. A. Yegorov presented detailed calculations showing how this could be achieved; the speed required is about 23,400 m.p.h., just 5,000 m.p.h. faster than the present satellites. Meanwhile, the Americans have stated their clear intention of circling the Moon at close range with probe rockets carrying "primitive TV devices" to scan the Moon—including the side man has never seen—and obtain "crude images of the main geographical features." One such project being developed in the United States uses a combination of the Thor I.R.B.M., the Vanguard second stage, and high-performance solid-rockets. Russia's ability to orbit 26 cwt is adequate proof that they have the means to send a heavy payload to the Moon any time they choose, given adequate control.


Spherical — Dia. 1 Ft 8 In
Spherical — Dia. 6·4 In
Vanguard Test Satellite (3¼ Lb)
Vanguard (21½ Lb)
6' 8"
Dia. 6·0 In
Explorer (30 8 Lb Complete with Final Stage Rocket Case)
U. S. A.
0 1 2 3 4 Feet
Spherical — Dia. 1 Ft 11 In
Sputnik 1 (184 Lb)
5' 6" (Approx.)
3' 4" (Approx.)
Sputnik 2 (1,118 Lb)
11' 8"
5' 8" (Approx.)
Sputnik 3 (2,919 Lb)
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U. S. S. R.
"ENGINEERING"

MICROWAVES UNDER DISCUSSION

Methods With Microwaves

A review of the development of microwaves in science and technology was given recently by Dr. R. Cockburn, Controller of Guided Weapons and Electronics, Ministry of Supply. He was giving an introductory lecture at the International Convention on Microwave Valves, held recently by the Institution of Electrical Engineers. Extracts from Dr. Cockburn's lecture, "Microwaves in Science and Technology," are given below. Other papers are summarised on the next page.

Twenty-five years ago the electronic engineer could be comfortably conversant with the whole field of propagation, aerial and earth design, modulation, detection and post and pre-detector amplification. Now the field of electronics embraces a wide range of techniques each requiring a lifetime-study of specialists; and its applications pervade the whole of industrial technology. During this conference we shall be considering only one aspect of electronics, the generation and use of microwaves. We are, therefore, not concerned with wavelengths outside the somewhat arbitrary band from 30 cm up to about 0·1 mm or 100 microns, the present limit for the generation of coherent radiation; nor shall we discuss processes after first detection.

By modern standards wartime radars were little more than laboratory designs of uncertain reliability; and they provided only the simplest of information. Target position was measured but usually only in two dimensions. There was no direct measurement of velocity, and clutter cancellation was in its infancy. Some auto-follow fire control equipment had been developed on the S-band but in general information was qualitative and only differentially accurate. Subsequent data handling was practically non-existent.

Since the war the original radar concept has been refined and extended, and new applications have arisen in communications, and in industry generally. This has been made possible by a series of developments in microwave technology and particularly in valve design. The power available from the magnetron has increased by an order of magnitude at the longer wavelengths and the klystron has been developed as a high power amplifier providing a source of phase coherent radiation. Two new valves, the travelling wave tube and the carcinotron now provide tunable oscillators and wide band amplifiers covering up to an octave of frequency. There has been a steady advance in engineering design and in reliability. This has been achieved only by methodical and unspectacular work over a long period, but microwave valves can now be designed with useful lives of over 1,000 hours.

Microwaves are now making an important contribution in the field of communication. During the last 10 years, the demand for multi-channel telephony has encouraged the use of the higher radio frequencies in order to accommodate the larger bandwidths required. It is, of course, considerably easier to modulate a 5,000 Mc/s carrier with several megacycles of information than one at 100 Mc/s. Communication engineers are now designing 960 channel telephone links and already thinking in terms of 2,000 channels. The growth of microwave point-to-point links, notably in Japan, the United States, and France, has been rapid. The frequencies used for these links lie in the range 2,000 to 11,000 Mc/s; and triodes, klystrons and travelling wave tubes have all been called into service. For instance, the Manchester-Kirk O'Shotts television link uses travelling wave tubes whereas the American coast-to-coast TD2 system uses triodes.

The wartime trend towards higher and higher frequencies has not been maintained in radar

Continuing Research and Development

applications. This is because no means has yet been devised for avoiding the scaling laws which control valve design, whereby power tends to fall off as the square of the wavelength; and because absorption and scattering becomes serious below the Q-band. However, in communications there may be applications which avoid both difficulties. These would depend on the almost loss-free propagation in hollow conducting pipes using high order modes. For these pipes to be of reasonable size, frequencies of at least 35 kMc/s and preferably 50-100 kMc/s must be used with the possibility of very wide bandwidths indeed. Absorption could be avoided by filling the pipes with a non-absorbing gas.

The continuous expansion of microwave applications has demanded and encouraged a corresponding expansion of technology which has in turn provided scientists with the resources for new fields of investigation. Very soon after Komfer had proposed his travelling wave tubes in which the electromagnetic field is amplified by coupling to a bunched electron beam, the nuclear scientists were exploring the reverse process in the linear accelerator in which the electromagnetic field transfers energy to the electrons. Electron energies in the range 4 to 40 MeV can be accumulated in this way using very high power microwave sources. The first centimetric valve to produce more than 10 MW pulsed power, the klystron developed by Ginzton, Chodorow and others at Stanford University, was designed particularly for this application. About 20 MW in a 2 microsec pulse has been obtained from this type of valve and even higher powers are possible. The linear accelerator has found applications in nuclear science, in medicine, and recently in the paint and plastics industry. An interesting development has been the generation of millimetric waves by making the emergent electron beam traverse a periodic array of magnets. Motz has used such an " undulator " to bridge the gap between microwaves and visible light.

Microwave techniques have been eagerly applied by physicists and chemists, particularly in the United States, to an examination of molecular structure; and during the past 20 years no fewer than five Nobel Prizes have been awarded for work on radio frequency spectroscopy. One practical outcome of this work is the advent of frequency standards based on atomic resonance. Studies have been made of absorption in gases, cyclotron resonance in semi-conductors, electron spin resonance in solids, resonance in plasma, and of superconductivity at microwave frequencies.

Cyclotron resonance has been particularly useful in investigating the mechanism of semiconductors and has provided a powerful method of unravelling the complicated behaviour of electrons and holes in the crystal lattice. Direct evidence has been obtained for both light and heavy holes in germanium and this has helped to clear up some of the finer details of their movement in transistor materials.

Perhaps the most striking research has been the study of resonances associated with electron-spin transitions in solids. In fields of a few thousand oersteds the energy required to flip an electron from down-field to up-field corresponds to a quantum of microwave radiation. The exact frequency of transition, the strength of the absorption, the width of the line, its shape and dependence on crystal orientation, and its saturation characteristics, together provide data of the most detailed kind about the resonating centre and its environment in the crystal. The technique has been applied to the study of donors, acceptors, and traps in semi-conductors, to colour and luminescence centres, to radiation damage and to alloy configuration. It is our greater understanding and control of crystal imperfections which is contributing to the development of the solid state maser; for it is now virtually possible to " tailor make " crystals having the complex properties for efficient amplification. Maser amplifiers have been shown to be practicable and developments in the next few years should lead to great advances in microwave technology.

In this short survey of the microwave field I have only considered the main trends and have not been able to cover every aspect. I have, for instance, not discussed the application of microwaves to very fast computers or the use of millimetric radiation for measuring the density of the plasma in the Zeta project. The applications of microwaves are so widespread that if there is a danger it is of dissipating effort in unnecessary duplication and minor refinements. We certainly need not worry about viability. Microwave technology is based on the dynamic interaction between electric charge and the electromagnetic field. Its range of inquiry extends from cosmic observations with radio telescopes to the fine structure of matter revealed by microwave spectroscopy. There is every reason to expect development to continue with increasing momentum.

Increasing Operating Frequencies, Reducing Noise

About 700 delegates attended the Internation Convention on Microwave Valves held by the Institution of Electrical Engineers. About 126 papers and contributions were discussed. Many papers were concerned with the increasing range of application of established types of valve, such as the magnetron, the klystron, and the travelling wave tube. Others were concerned with devices in the early stage of development, such as paramagnetic amplifiers and masers. A further group of papers contained theoretical proposals for new devices. Some of the contributions in the second two groups are summarised in the following article.

PARAMETRIC AMPLIFIERS

The principle of parametric excitation for use in microwave amplification and frequency conversion is attractive in a number of ways, one of the most important being the low noise behaviour. Conventional non-parametric amplifiers use electron beams which are emitted from hot cathodes. The high temperature results in high initial beam noise, which is extremely difficult to reduce beyond a certain point. Amplifiers based on the parametric principle do not necessarily require electron beams. The active element may consist, for example, of a solid semiconducting or ferrimagnetic material. In this way, high temperature is eliminated as the basic cause of noise.

In a paper " Microwave Parametric Amplifiers and Converters," the authors, G. Wade and H. Heffner, pointed out that the parametric amplifier does not involve quantum mechanical phenomena in any essential way, the amplifier process being explainable in terms of classical circuit concepts. However, in any particular physical embodiment, quantum effects may be involved in determining the relationship between the material properties and the classical circuit elements.

The fundamental parametric circuit involves a variable-energy storage element which couples together two resonant tanks. It is essentially the same for both amplifier and converter. If a load is coupled to one of the tanks, the circuit acts as an amplifier for a signal coupled into the loaded tank at its resonant frequency. It acts as a converter for a signal coupled into the other tank at its resonant frequency. Regardless of the nature of the variable element used, said the authors, analysis shows that the product of the voltage gain and the fractional bandwidth is relatively small and depends only on the Q factors of the tanks and the relative frequencies. This product can be increased by using multiply-tuned circuits, by making the amplifying frequency the lower of the two resonant frequencies involved, or by using a travelling-wave circuit. The bandwidth of the converter is the same as that of the amplifier.

The noise figure depends both on the amplified thermal noise in the two resonant circuits and upon the equivalent shot noise introduced by the particular variable element used. The thermal-noise contribution can be minimised in the amplifier by coupling the source heavily to the amplifying-frequency resonant circuit. It can be further minimised by making the amplifying frequency the lower of the two resonant frequencies involved. The semi-conductor diode and ferrimagnetic versions appear to have small shot-noise contributions, so that at room temperature these amplifiers might be designed to have a noise figure in the vicinity of 1 dB.

In an introductory talk on " Atomic and Molecular Generators," the author, Dr. K. W. Stevens, suggested that the main difficulties in understanding parametric amplifiers and masers arose because of the unfamiliar nature of the substances which were being used. He went on to discuss a simple model of a parametric amplifier that could be used as a basis on which to build up to the more complex concept of practical devices. To do this, two circuits are described which are tuned to angular frequencies ω and ω-ω_1 and coupled by a mutual inductance that varies with time at an angular frequency ω. Conventional circuit analysis shows that such a system can act both as an amplifier and as a frequency changer. The author then considered the system from a quantum theory aspect.

In such an amplifier the energy is being supplied at the frequency ω. Thus the energy is actually being supplied in quanta of magnitude $\frac{h\omega}{2\pi}$. To amplify ω_1 a system must be devised whereby quanta at ω_1 are produced in number proportional to the power of the signal to be amplified. This can be achieved if the quanta at ω can be persuaded to undergo " fission," described by $\omega \rightarrow \omega_1 + (\omega\text{-}\omega_1)$, at a rate controlled by the signal. It does not matter that the quanta at $(\omega\text{-}\omega_1)$ perform no useful function, though they can be used for frequency conversion. Noise in the device arises when quanta at ω_1 are produced in numbers unrelated to the power of the incident signal.

Dr. Stevens then went on to discuss a system in which a precessing magnetic moment couples the two tuned circuits together. The precessing moment behaves like the varying mutual inductance of the first arrangement. Alternatively, it can be regarded as a system that absorbs quanta at ω and then, through its interaction with the circuits, provides a fission process. It is not necessary for the moment to be due to a ferro or ferrimagnetic, and it can be due to a paramagnetic.

LOWER-FREQUENCY PUMPING

Parametric amplification has previously been carried out with the power source operating at a higher frequency than the signal source. For this reason the paper " A Parametric Amplifier Using Lower-Frequency Pumping," by K. K. N. Chang and S. Bloom, was of some interest. The authors said that the principle of parametric amplification with low-frequency pumping had been verified both in a non-linear inductance and in a non-linear capacitance system. In the former a ferrite core was used and a 30 per cent power gain was observed at a signal frequency of 10 Mc/s and a pump frequency of 7 Mc/s. The low gain was attributed to the small degree of non-linearity. The non-linear capacitance system gave much better results because of the larger degree of non-linearity. Here a reversed-bias junction diode was used as the non-linear coupling between a signal circuit tuned to 380 Mc/s, an idling circuit at 220 Mc/s, and a pumping circuit at 300 mc/s. A stable net

gain of 20 dB was obtained at 380 Mc/s with a pump power of only 30 mW. The full percentage bandwidth was of the order of 0·3 per cent and the noise factor about 10 dB.

Another variation of the parametric amplifier was suggested in a paper "Parametric Amplification of Space Charge Waves," by A. Ashkin, T. J. Bridges, W. H. Lousell, and C. F. Quate. The authors said that the principle of parametric amplification could be applied to an electron beam to amplify either the fast or the slow space-charge wave. In the new mechanism the beam is heavily modulated with a frequency equal to nearly twice the signal frequency. With this modulation the normal space-charge waves will grow exponentially with distance. Experimental curves showed a signal of 4 Gc/s amplified with a pumping frequency near 8 Gc/s. The authors remark that the presence of the fast space-charge wave implied a kinetic power in the beam which is in excess of the d.c. power. It has not been possible, therefore, to amplify this wave when the d.c. energy was the source of power, as in a conventional klystron. However, in the parametric amplifier the energy for amplification comes from the high-frequency "pump" oscillator and it becomes possible to amplify the fast wave. The noise power at the signal frequency in the fast space charge wave can in principle be removed from the beam with a passive circuit. This in turn implies that amplifiers with much reduced noise figures should be possible.

THREE-LEVEL MASER

"Theory of Three-Level Paramagnetic Masers," by P. N. Butcher, was a paper presented in four parts and devoted to one particular type of maser. Quantum mechanical techniques were used for the theoretical descriptions.

A new type of solid-state maser amplifier which amplified continuously was proposed in 1956. The active material is a crystal containing paramagnetic ions having at least three low-lying Zeeman levels. Only three of the energy levels are vital to the operation of the device. It is convenient to number them 1, 2, and 3 in order of increasing energy. A relatively intense "pump" field is applied at the resonant frequency of the (3, 1) transition. It creates a steady-state condition in which the populations of the levels 3 and 1 are equal. There are then three possibilities:

(*a*) The population of level 3 is greater than that of level 2.

(*b*) The population of level 2 is greater than that of level 1.

(*c*) The populations of levels 1, 2, and 3 are all equal.

In case (*a*) amplification is possible at the resonant frequency of the (3, 2) transition, in case (*b*) it is possible at the resonant frequency of the (2, 1) transition, and in case (*c*), which is not likely to occur, amplification is not possible at any frequency. The populations of the various levels are maintained by the pump field, so that the device amplifies continuously.

An oscillator using this principle has been constructed. It used a crystal of lanthanum ethyl sulphate doped with gadolinium ions, which have eight low-lying Zeeman levels. An amplifier has also been constructed using a crystal of potassium cobalt-cyanide doped with chromium ions, which have four low-lying Zeeman levels.

Dr. Butcher's paper was concerned with the quantum-mechanical aspects of the theory of such amplifiers. It was assumed that in the presence of the pump field, amplification was possible at the resonant frequency of the (3, 2) transition. The author pointed out that the statistical knowledge that we have about the state of an ion in the presence of both the pump and signal fields is most conveniently described by a density matrix. He then set up the equations of motion of the density matrix and derived an approximate steady state solution. The fractional population differences, magnetic polarisation densities, susceptibility tensors, and power-dissipation densities at the pump and signal frequencies were then determined. These results were used in Part 2 of the paper to evaluate the operating characteristics of various maser amplifiers.

The author pointed out that there remain many problems to be studied in the physics of three-level solid state masers. From an experimental standpoint the most pressing need is for measurements of the six relaxation parameters which the calculation showed significant: the spin-spin relaxation times, the spin-lattice relaxation times, and the Overhauser parameters. At present these parameters are not all known, even approximately, for any paramagnetic material. On the theoretical side there is need for calculations of the matrix elements of the magnetic moments of the paramagnetic ions in various crystals. And, adds the author, there remains the central problem of developing a complete treatment of the response of a paramagnetic crystal to applied microwave fields, taking proper account of the coupling of the ions to their surroundings and to each other instead of introducing *ad hoc* relaxation terms into the equations of motion of the density matrix. Dr. Butcher suggested that recent developments in the theory of nuclear relaxation give some indication of how this might be achieved. From an engineering viewpoint, he suggested that the most important problem in the design of maser amplifiers is that of achieving larger bandwidths the solution probably lying in the development of travelling wave masers.

"Travelling-Wave Solid-State Masers," a paper by A. E. Siegman, P. N. Butcher, J. C. Cromack, and W. S. C. Chang, took up this topic and produced an expression for the gain per free-space wavelength. It was noted that with presently achievable magnetic Q-factors, very low group velocity, low pitch, narrow band structures are required for sufficient gain in a reasonable length. Also since the travelling wave maser normally amplifies in both directions, instability due to mismatches is a difficult problem. The authors had carried out a detailed analysis of a string of coupled negative-Q-factor resonant circuits and obtained curves showing the variation of gain with frequency. Techniques for making the maser non-reciprocal were proposed but none seemed particularly attractive to the authors at present.

WAVES AND ELECTRONS

A means of obtaining direct interaction between waves and electrons, without the intervention of resonant cavities was discussed in a paper "Fast-Wave Interactions with an Electron Film at Cyclotron Resonance," by A. Karp. The system is under investigation with a view to producing electron devices for increasingly shorter wavelengths. The electrons are used as a thin cloud or film lying upon a metallic emitting surface under the combined influence of a relatively weak, normal, steady electric field and a relatively strong, tangential, steady magnetic field. The radio frequency signal is propagated as an ordinary fast wave polarised normal to this surface. When steps are taken to control the build-up of space charge (for example, by the use of a small, auxiliary steady magnetic field, orthogonal to the principal one, to effect rapid "drainage" of electrons out of the film) the electrons in the film possess rotational energy which can be transferred to the wave. Like the ammonia gas in an ammonia maser, the electron film can be considered as a bulk medium that interacts with radiation at a frequency critical to the medium. In this case it is the electron "cyclotron" frequency. This can be evaluated in megacycles per second by multiplying the magnetic field intensity, in gauss, by 2·8.

The author explained that for zero space charge the electrons in the film can be organised or sorted (analogous to "focusing" in the ammonia maser) by an infinitesimally small radio frequency signal. That is, the electrons emitted at times such that they would absorb energy from the wave are immediately returned to the cathode, leaving only electrons capable of releasing energy to the wave. This system, said the author, should spontaneously emit radiation, or oscillate at the cyclotron frequency.

With little space charge, the degree of organisation resulting from the return of unfavourable (absorbing) electrons to the cathode is proportional to the radio frequency field. The rate of energy release by the organised or favourable electrons is also proportional to the radio frequency field (for small signals) so that a linear amplifier is obtained. The author explained that such a device had been built and tested at wavelengths near 8 mm. The construction was large compared with the wavelength and free from any mechanical structure that might limit the frequency of operation, which should be limited only by the magnetic field strengths available. Substantial amplification was observed but further work is required to obtain better control of drainage, which also affects the bandwidth, and waveguide losses. (Unlike the travelling wave tube, insertion losses for the new device subtract directly from the gain.) The device also operates as a detector.

With high space-charge, only absorption of the wave can occur. This mode of operation, which was studied experimentally at wavelengths near 5 mm, may have application in a fast acting (millimicrosecond) microwave switch or modulator controlled by the potential on an electrode drawing no current.

BEAM AMPLIFICATION

In a paper "Some Proposals for Generating High Frequency Electromagnetic Waves Using the Doppler Effect," by R. B. R. Shersby-Harvie, it was shown theoretically that power may be transferred from a fundamental frequency oscillation to a harmonic frequency oscillation in a simple form of waveguide or resonator through the medium of a beam of bunched electrons. A possible application would be as a frequency multiplier for generating millimetre wavelengths for experimental purposes. A numerical example, with various idealised assumptions, considered a device for producing the fifth harmonic of a 1 cm signal. The author showed that the device should be capable of outputs exceeding one-tenth of the driving power and be capable of handling any peak powers that are, at present, available. The physical dimensions of the device were large enough to avoid any serious constructional problems, and it appeared capable of producing higher power millimetre waves than can be obtained with crystal multipliers.

"Microwave Amplification Using an Unstable Electron Beam in Crossed Electric and Magnetic Fields," by D. J. Harris, described an experiment in which the amplitude of the microwave signal on a velocity-modulated strip electron beam in crossed electric and magnetic fields was measured as a function of position along the beam by means of a moving cavity. Amplification was detected and the growth rate of the signal was found to be of the order of 2 dB/cm for a 500 eV beam with a current of 40 mA per centimetre of beam width.

The system makes use of the fact that under certain conditions electron beams can be made unstable, in that beam disturbances tend to grow in magnitude along the beam. If this instability could be harnessed to give useful microwave amplification the system might raise the upper power and frequency limits set by the slow wave structure in a conventional travelling wave tube. It can be shown that a beam of electrons in crossed electric and magnetic fields between a pair of parallel conducting planes is essentially unstable, and the resulting amplification mechanism is known as the "dicotron" effect. The amplification takes place by virtue of image-charge and space-charge forces only, without the need for continuous interaction with the electric field on a nearby slow wave structure.

In the author's experiment a wavelength of 12 cm was chosen to give convenient dimensions of the tube and to fit in with available equipment; the measured value of the amplification obtained agreed reasonably well with the value predicted theoretically. It should be possible to build practical tubes using this mechanism, with particular advantage at wavelengths in the millimetre region.

Continuing **Research and Development**

MEASURING LOCAL STRAIN UNDER STATIC LOAD

Rapid Replica Technique

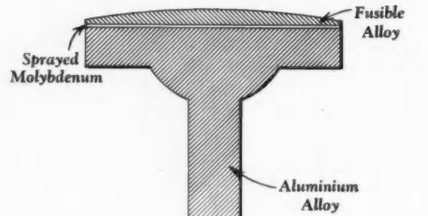


Fig. 1 The replica platen is coated with a fusible alloy.

A new rapid method for measuring directly local strains in a structure or test specimen under static loading, demonstrated for the first time at the recent Physical Society Exhibition, is arousing considerable interest among structural test engineers. Briefly, the technique is to inscribe a light pattern of scratches on the surface of the structure, and to take replicas of this pattern firstly with the structure unloaded, and then under load. From the two replicas, compared under a measuring microscope, the relative displacements under load of the inscribed lines can be determined, and elastic strains can thus be deduced to within 0·005 per cent over a 0·5 in gauge length. Plastic deformations over a small area can be fully explored to a sufficient accuracy using gauge lengths of the order of 0·01 in.

The replica technique, devised in the Structures Department of the Royal Aircraft Establishment, Farnborough, was developed in the first place for such applications as the investigation of plastic deformation in the vicinity of a stress raiser; and the determination of "manufacturing" stresses in an aircraft structure. In this application, replicas are taken on sheet components, before and after building them into the aircraft structure, and also after the structure has been subjected to manoeuvring loads. The technique is also available to supplement the use of strain gauges during static tests, it being applicable in a matter of minutes; and for the measurement of creep in heated aircraft structures, by taking replicas before and after the heating is applied. Another use for which the replica technique is finding application is the measurement of permanent deformation of a specimen undergoing a lengthy fatigue test—possible without removing the specimen from the test machine; and there are possibilities for its use in the routine examination of aircraft, vehicles, bridges or similar structures, to detect incipient failure.

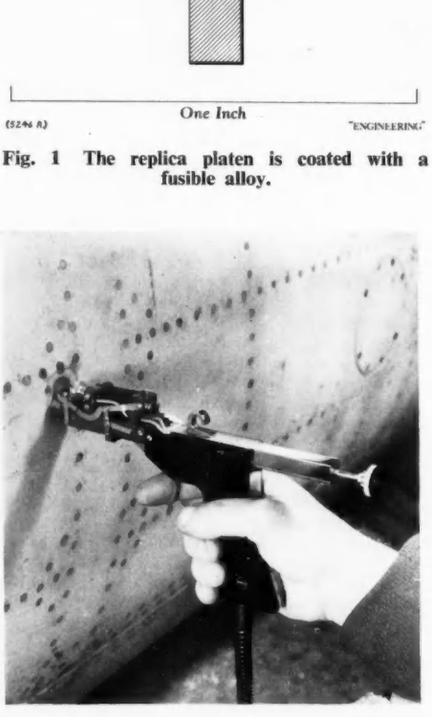


Fig. 2 A light spring gun, fitted with a heater element, is used to apply the replica to the specimen surface.

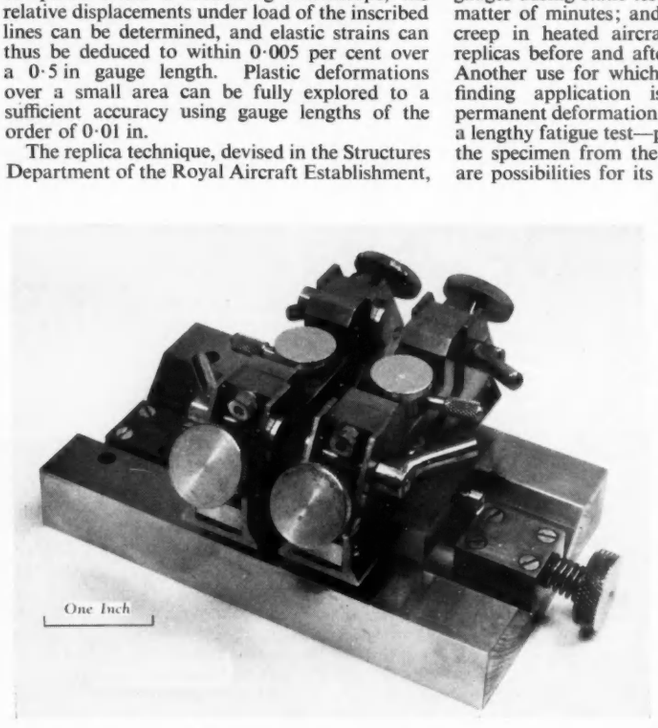
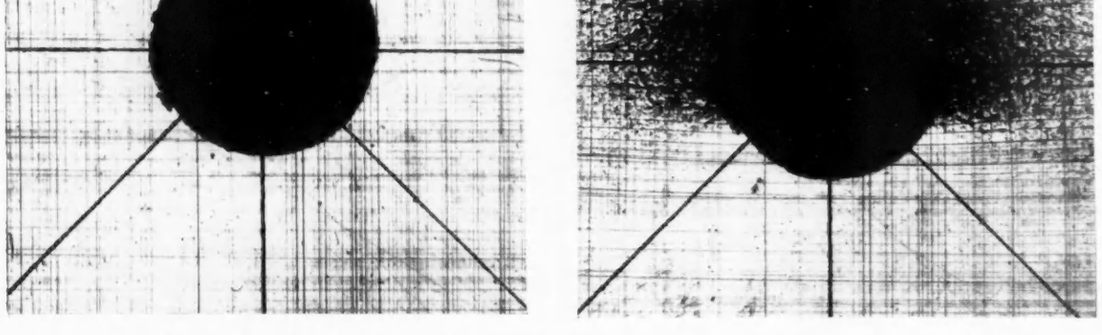


Fig. 3 Two replicas, taken before and after loading, are mounted in an adjustable sliding block which permits orientation of the replicas so as to give pseudo-coincidence under a measuring microscope.

Considering now in rather more detail how the replica is made: the first step is the preparation of the structural specimen, which may have a curvature as great as 6 in radius. The surface is polished locally, and a random rectangular scratch pattern is inscribed on it with rouge paper, using a flexible template. Fine guide lines are also supplied by a sapphire needle, parallel to the scratch pattern. These lines, being only 0·0001 - 0·0002 in deep, and having a smooth profile, do not constitute stress raisers.

The material used for making the replicas—on which the success of the technique depends—has been the subject of months of development work. Finally, the desired fidelity and stability have been obtained from a fusible alloy of Wood's metal with 14 per cent indium—an alloy which liquefies at a temperature of 60° C, and solidifies at 50° C; between these temperatures it is plastic. Small mushroom shaped replica platens (Fig. 1) having a coefficient of expansion identical with that of the structural specimen have been prepared beforehand; the head is sprayed first with a coating of molybdenum, to give adhesion, and finally with the fusible alloy, the surface of which is machined to a slightly convex profile.

To make the replica, a platen is inserted in a spring gun (Fig. 2) which is fitted with a heating



Figs. 4 and 5 Microphotographs taken from replicas of a hole in a test strip, before and after application of a tensile load.

element and a thermocouple which straddles the platen and is connected to a potentiometer and a galvanometer. The spring gun is held close to the specimen, aiming at the scratch pattern, and when the temperature of the platen reaches 53° the operator fires the gun. The fusible metal, now in a soft plastic condition, conforms to the shape of the specimen and reproduces faithfully the scratch pattern. After some 30 seconds the platen has cooled, and is then removed. The fusible alloy, now hard, separates readily and cleanly from the surface of the specimen. The flash is then trimmed away.

The finest scratches are reproduced on the surface of the fusible metal which then constitutes an accurate mounted replica of good durability. A pair of replicas taken from the same measuring station at different loads on the specimen gives a complete record of surface strains over the area of the platens. For measurement, the two replicas are mounted in an adjustable sliding block (Fig. 3) under a microscope and are brought to approximate pseudo-coincidence by various adjusting screws. Suitable scratches are selected, and relative displacement measurements between one replica and the other are made on the micrometer eyepiece by traversing the sliding block back and forth. In this manner it is possible to determine all the components of strain in the plane of the surface. The random spacing of the scratches has a definite virtue in that lines may be identified without numbering.

Since the platens are made of metal of the same coefficient of expansion as the structure, the replicas are compensated for variations in the temperature of the structure—this compensation has been verified between 17° C and 40° C. The absolute accuracy of the replicas is generally within one micron and the overall precision is effectively limited only by the microscope. Figs. 4 and 5 show microphotographs taken from replicas of a hole in a tensile strip and Fig. 6 is a diagram of the principal elongations and their directions derived from measurements on the replica pair over an area measuring 0·1 in by 0·05 in.

The special characteristics of the technique are: (*a*) there is no serious restriction on the size or location of the structure. (*b*) With a smooth surface structure, the preparation of the scratch pattern and the taking of replicas is very rapid. (*c*) There are no attachments to the structure. (*d*) Single or multiple measurements of strain over a small area may be made with equal facility.

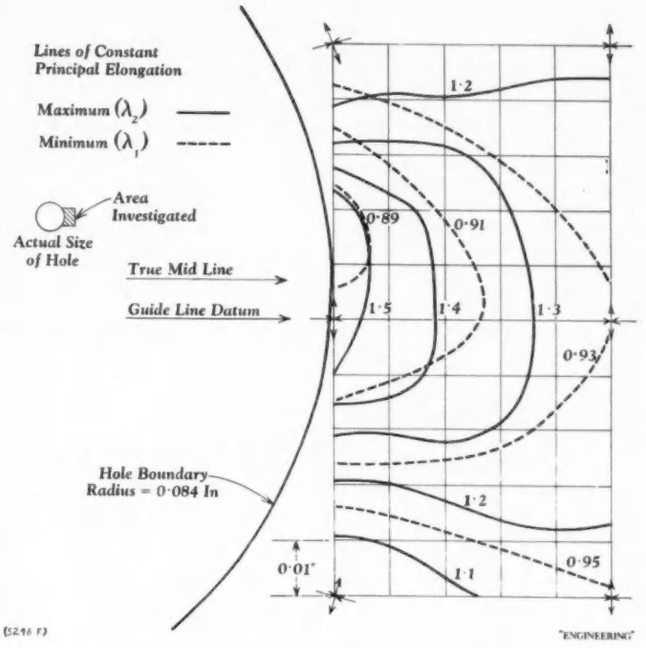


Fig. 6 The principal elongations and their directions over an area 0·1 in by 0·05 in, derived from Figs. 4 and 5.

Design

CLOSELY CONTROLLED ALTERNATING CURRENT SUPPLIES

The advanced techniques that have been built into the guided weapons of to-day, in many instances, will be available to industry generally tomorrow. Already the principal manufacturers of a.c. power packs for weapon services are engaged in market research with a view to setting up a commercial range of precision high-frequency alternators which, they believe, should fulfil a need wherever there is a demand for closely controlled power supplies—such as in ship-borne navaids and radar, storage memory banks and possibly in the nuclear energy field.

It may come as a surprise to engineers outside the aircraft and weapons industries to learn that the firm responsible for supplying electrical power packs for 90 per cent of Britain's production guided weapons, including the Bristol Bloodhound, the Armstrong Whitworth Sea Slug, and the de Havilland Firestreak, is de Havilland Propellers Limited, Hatfield. In fact, when they entered the field in 1951, none of the established electrical firms had had occasion to acquire experience in the making of rugged light-weight alternators with tight tolerances on voltage and frequency; whereas de Havilland had a useful background knowledge of precision mechanisms, electrical and hydraulic, gained in the manufacture of constant-speed propellers.

The characteristics demanded of an alternating current supply for a guided weapon are: extremely close regulation of voltage and frequency, down to plus or minus 1 per cent, coupled with a high quality wave form; the ability to start-up rapidly with no warm-up period; and the ability to withstand violent acceleration and vibration. Continuous rating is not demanded for missile power packs, and they are " lifed " at up to 100 hours. De Havilland also make, however, larger aircraft power packs for pre-launching weapon services which are continuously rated.

The principal design features of the de Havilland power packs are the compact assembly of the alternator, prime mover and controller; keeping to the minimum the number of moving, and particularly sliding parts, such as brushes, hence the use of inductor alternators for the main high-frequency single-phase supply and of magnetic amplifier controllers for voltage and frequency regulation. To avoid interference with the guidance system, the frequency chosen is 2·4 kc/s, and the voltage is 115 V in the case of missile power packs; and in the aircraft power packs, whatever value above 115 V suits the application, to compensate for line losses. Aircraft power packs, ranging in output from 1·75 kW to 4·5 kW, are driven by hydraulic swashplate motors fed from the aircraft hydraulic supply. They are air-cooled by ram air.

The intermittently-rated power packs for missiles are of two main types: turbine-driven, or with a hydraulic gear-motor drive. The turbo-alternators may be driven either by compressed air, or gas derived from the combustion of cordite or iso-propyl nitrate; they are rated from 300 to 1,800 W, and some power packs incorporate a smaller three-phase 400 cycle salient-pole machine on the same drive shaft as the main alternator. A larger turbo-alternator, driven by steam generated by the catalytic decomposition of hydrogen peroxide, is also under development. The hydraulic gear-motor power packs are rated at 450-900 W and they, too, incorporate a 55 W 30-36 V three-phase salient-pole alternator in tandem with the main high-frequency alternator.

When it comes to commercial applications, it may well be that de Havilland will offer a different choice of frequency since 2·4 kc/s is not

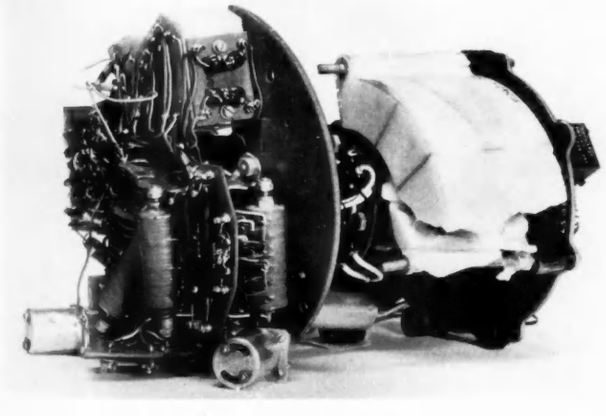


Fig. 1 (left) This air-turbine driven high-frequency power pack, used in a guided-missile test round, was recovered from the sands of Woomera desert after falling from about 25,000 ft. Although badly damaged externally, it still functioned within the specified limits.

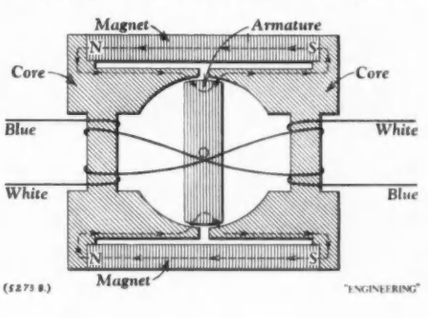


Fig. 2 (right) The Laws relay.

Continuing **Design**

likely to have many industrial applications. It is, they state, a fairly simple matter to fit a different alternator to an existing power pack, and to adapt the controller to suit the re-designed alternator.

In the turbo-alternator units, the frequency of 2·4 kc/s has made possible a single-shaft layout. A turbine operating at 2,400 r.p.m. drives directly an inductor alternator with a six-pole rotor and a four-pole stator wound with two field coils and two output coils. There are no rotating windings or slip rings, but a stack of condensers is connected in series with the output windings, tuning the machine to 2,400 c/s and thus obviating the undesirable high impedance inherent in an inductor alternator. The same type of alternator is adopted in the hydraulically driven power packs, but in this case a two-stage step-up gearbox is interposed between drive-motor and alternator. In the continuously rated power packs, the gearbox is force-lubricated and scavenged, but in the intermittently-rated hydraulic power packs a dry step-up gearbox, employing Bakelite No. F17297 gears meshing with steel pinions, is used.

Voltage regulation, by adjustment of the field current, is fairly orthodox; frequency regulation is less conventional. The alternator output is fed, through a transformer, into two resonant circuits, one tuned 300 c/s above and the other 300 c/s below the nominal alternator output frequency. Thus if the alternator frequency varies, the output from one tuned circuit will rise while the other falls. In the case of hydraulically-driven units, these differential outputs are used to control a magnetic amplifier, the push-pull output of which drives a Laws relay operating the selector valve of a two-stage hydraulic servo regulating the opening of a throttle in the inlet line.

Fig. 2 shows the principle of the Laws relay. When the alternator is off frequency, the currents in the two windings vary differentially. This causes the pivoted soft-iron armature to rotate, and thus indirectly to adjust the speed of the machine through the servo mechanism. In air-driven turbos, a directly-operated rotary throttle valve can be used, but in the case of hot-gas drives a servo-operated tapered needle valve is more practical as the gas stream is usually contaminated in a manner which could clog the rotary type. In later hot-gas turbo units, other means are being developed (described in a subsequent paragraph). Hydraulic machines generally have throttles of the rotary " hole-and-hill " sleeve-valve type (Fig. 3). When swash-plate motors are used, a second stage of speed regulation is obtained by altering the angularity of the swashplate to vary the delivery. This enables the throttle opening to be kept as large as possible, to minimise energy losses and over-heating.

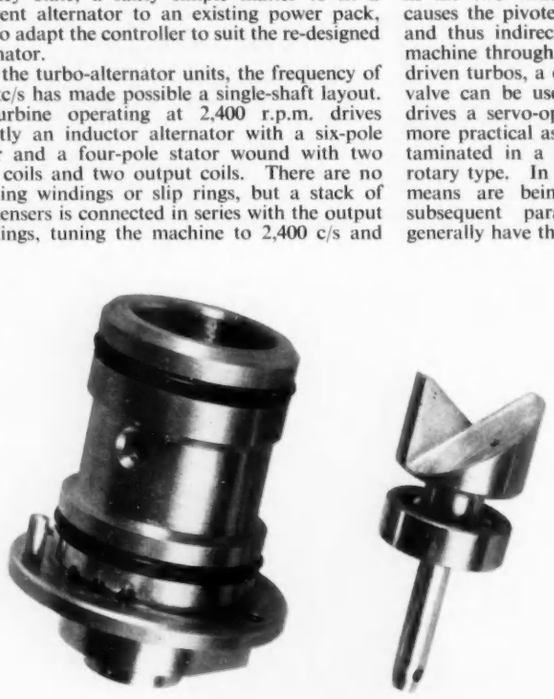
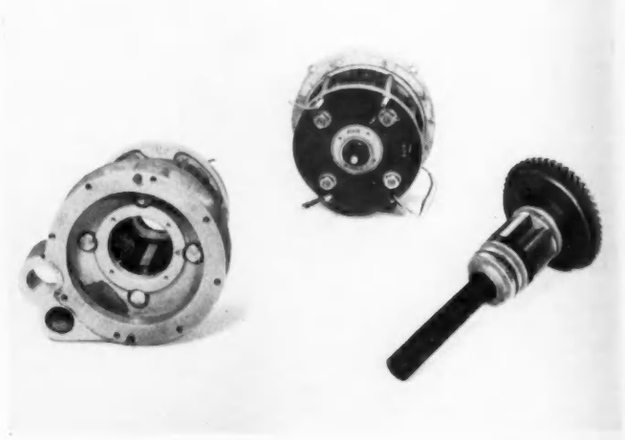


Fig. 3 (left) " Hole-and-hill " throttle valve of hydraulic motor.

Figs. 4 and 5 (below) Parts of the hot-gas turbo-alternator unit recovered at Aberporth recently. The controller (Fig. 4) worked perfectly in spite of chassis distortion. The rotor (Fig. 5) remained perfectly balanced and fit for further tests.

Fig. 1 shows the still serviceable remains of a crashed compressed-air driven turbo-alternator pack—comprising inductor alternator surrounded by a condenser block; the turbine unit and its throttle; and the controller unit embodying voltage and frequency regulators. The particular unit shown here is of special interest in that it was recovered after firing trials at Woomera. Dropping from a height of 25,000 ft, at supersonic speed it buried itself in the sands of the rocket range. Retrieved and sent back to England untouched, de Havilland found it in working order when one broken electrical connection had been made, and regulating within the specified close limits. This is not an isolated case: quite recently, it may be recalled, there was an " incident " at Aberporth when a trial round went off its course and returned to the launching site. The power pack from this vehicle (Fig. 4) was also retrieved by the missile company concerned (not de Havilland) who started to dismantle it before returning it to Hatfield. In this case, the power pack was not in working order, but preliminary examination showed that this was due solely to a slight distortion of the stator, causing the rotor to foul it. The rotor itself was less than 0·0001 in out of tolerance; and the controller, in spite of the fact that its chassis was bent by the impact, was still able to function adequately.

This later power pack, a hot-gas driven turbo-alternator, employs an entirely different speed control mechanism from the earlier version



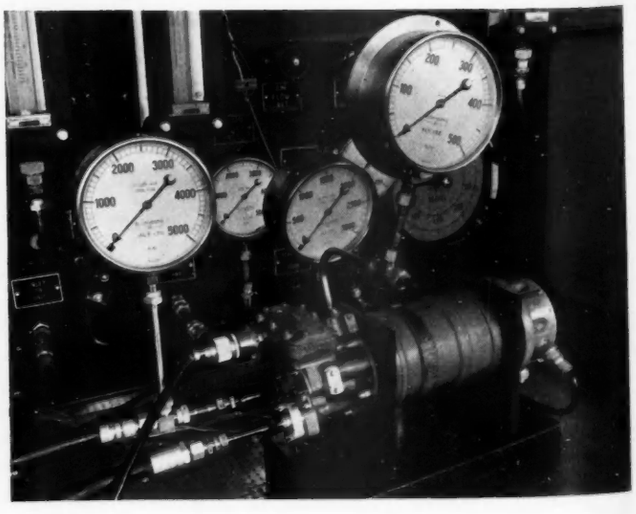


Fig. 6 (right) Mounted on the test rig is a low-speed high-frequency oil-cooled alternator directly driven by a swashplate oil motor.

Continuing Controlled A.C. Supplies

shown in Fig. 1. Because cordite tends to foul moving parts, de Havilland decided to eliminate the throttle control and, instead, a slave alternator is used to maintain constant torque on the turbine irrespective of the main alternator load. The power developed by the slave alternator is dissipated through a heater element. This arrangement has the disadvantage of being heavier than the original unit, but is very reliable. A still later development, not yet in production, is an eddy current brake integral with the turbine wheel, which brings the weight down from 23 lb to 14 lb.

In the hydraulically-driven power packs there is a further development, not yet in production, which should be mentioned—a low-speed high-frequency alternator (2·4 kc/s) continuously rated at 1¾ kW, directly driven at 5,750 r.p.m. by a swashplate motor. Instead of cooling the alternator by ram air, as in the current aircraft power packs, an ingenious system of oil cooling is used. To minimise the oil drag, the rotor is "potted" in Araldite so that only the extreme tips of the poles are clear of the resin; and the oil used for cooling is, in fact, the exhaust from the drive motor. Tests have shown that, in comparison with the orthodox air-cooled geared unit, the additional drag due to the rotor running in oil is more than counterbalanced by the saving in resistance of the gearbox—an overall reduction of resistance of 3 per cent is claimed, and the unit is, naturally, appreciably more compact and lighter in weight.

HAMS HALL "C"

The official opening on 9 May of the Hams Hall C station marked the completion of work on the group which was begun by the City of Birmingham in 1926. Work on "C" was begun in 1952 and the six sets there, each of 60 MW, bring the total installed capacity of the group up to 930 MW. The design and construction of the C station was carried out under the supervision of the Northern Group construction staff of the Midlands Division, now part of the Midlands Project Group.

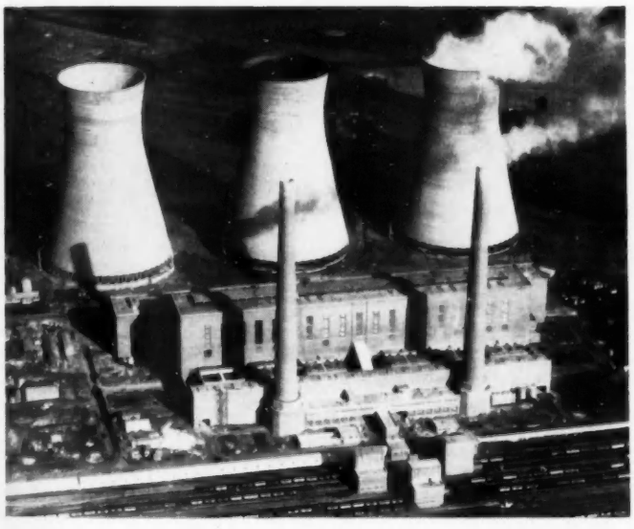
The station was designed at the time of the steel shortage and therefore has the turbine room and the switchgear bay built in reinforced concrete. The cladding of the whole is in brick. The six machines are arranged longitudinally with their centres at 96 ft 3 in intervals. This allows for straight rotor withdrawal. There is no sub-basement so that the danger of flooding is removed. Unlike the A station, for which the circulating water make-up is drawn from the effluent of the local sewage plant, the C station draws its supply from the river Tame, which forms one of the boundaries of the site. The six Simon-Carves boilers rated at 550,000 lb of steam per hour at 950 lb per sq. in and 925° F, feed the six 60 MW General Electric turbo-generators. Three Film cooling towers serve the whole station, each receiving the water from the twin Worthington-Simpson condensers of two machines. The consulting civil engineers for the station were L. G. Mouchel and Partners.

The boilers have been designed to burn low grade fuel, calorific value about 4,000 B.t.u., obtained by mixing slurry with coal from the local pits. The slurry has an ash content of about 50 per cent and a moisture content of 18 per cent. A high air temperature is therefore used—540° F—to drive off the moisture. The Babcock and Wilcox ash handling plant feeds to three lagoons which are dug out in turn; some of the ash, about 40,000 tons a year, is supplied to a plant that Thermalite Limited have constructed nearby to make ash blocks for structural purposes. The three Hams Hall stations produce in all about 300,000 tons of ash per annum. Oil is used for starting up, there being six Fuel Firing initiators in each boiler. Three additional initiators are included for temperature matching on two shift operation.

Internally one of the main features is the amount of natural lighting that has been used. Both roof lights and side windows are there and, together with the colour scheme employed, a very light and airy impression is given. This applies both in the control room and in the turbine hall, which latter has glass screens around the control desks for the machines. All the lagging of the pipe work is metal cased. Panels divide the boiler house from the turbine hall.

At present the station is running on base load, but provision has been made for changing to peak load operation when some of the other stations now under construction are completed. To help improve the load factor, electric floor heating has been installed in the control room and the canteen (which last supplies all three stations) and floor heating has been encouraged locally. In Wolverhampton, one block of flats alone draws 2,000 kW for this purpose and its use is spreading to private houses stimulated by the cheap rates available.

Fig. 1 (left) Hams Hall "C" has six 60 MW sets installed. It is designed for burning coal mixed with slurry. Fig. 2 (right) Natural lighting and a pleasant colour scheme are features of the turbine hall.



NOTICES OF MEETINGS

British Computer Society

LONDON
Annual General Meeting and Presidential Address. Northampton College of Advanced Technology, St. John Street, E.C.1. Mon., 16 June, 5.30 p.m.

Combustion Engineering Association

GLASGOW
Discussion on "A Survey of Boiler Cleaning Methods," at 10.30 a.m. and a Discussion on "A Comparison of Space Heating Systems," at 2.30 p.m. Scottish Region. Grand Hotel, Charing Cross, Glasgow, C.3. Wed., 11 June.

Institution of Civil Engineers

LONDON
Annual General Meeting. Tues., 10 June, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
Institution Conversazione. Royal Festival Hall, S.E.1. Wed., 25 June, 7.30 p.m.

Institution of Engineering Designers

LONDON
"Engineering Design: The Background and Basis of Contemporary Life," by Hugh Clausen. Manson House, 26 Portland Place, W.1. Thurs., 12 June, 6.30 p.m.

Institution of Mechanical Engineers

CARDIFF
"Light Mechanical Engineering in South Wales," by H. A. V. Bulleid; and "Some Mechanical Equipment in the Heavy Industries of South Wales," by W. F. Cartwright and I. S. Scott-Maxwell. Ordinary Meeting of the Institution. Rearden Smith Lecture Theatre, Cardiff. Wed., 18 June, 10 a.m.

Institution of Public Health Engineers

LONDON
Summer Meeting. Annual General Meeting, at 4.45 p.m. Tea at 5.15 p.m. Discussion on "The Hogsmill Valley Works of the Hogsmill Valley Joint Sewerage Board," at 6 p.m. Caxton Hall, off Victoria Street, S.W.1. Fri., 13 June. (A visit to the Hogsmill Valley Works, near Surbiton, Surrey, will be paid on Saturday morning, 14 June.)

Royal Meteorological Society

LONDON
Various short papers including "The Use of Balloons in Atmospheric Pollution Research," by D. H. Lucas, G. Spurr and F. Williams; and "The Hydrogen Content of Atmospheric Air at Sea," by E. Glueckauf and G. P. Kitt. Wed., 18 June, 5 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

British Computer Society, 29 Bury Street, St. James's, London, S.W.1.
Combustion Engineering Association, 6 Duke Street, St. James's, London, S.W.1. (WHItehall 5536.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland Place, London, W.1. (LANgham 8847.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Public Health Engineers, 118 Victoria Street, London, S.W.1. (VICtoria 3017.)
Royal Meteorological Society, 49 Cromwell Road, South Kensington, London, S.W.7. (KENsington 0730.)

Book Reviews

ORIGINS OF ENGINEERING

A History of Mechanics. By RENÉ DUGAS. *Routledge and Kegan Paul Limited, Broadway House, 68-74 Carter Lane, London, E.C.4.* (100*s.*)

The reviewer of this book, who is an engineer, read to page 349 with considerable enjoyment and profit, although he found the chapter on Lagrange stiff. From then until page 458, when the treatment of Classical Mechanics ends, he was frequently well out of his depth, and thence to the end of the book on page 672 he was entirely lost in the discussion of relativistic, wave and quantum mechanics. So he showed it first to an engineering mathematician, who thought it superb and promptly bought a copy for himself, and then to an expert on the last portion, who damned it heartily; what follows is a *réchauffé* of these three viewpoints.

The book is badly translated from the French and printed in Switzerland on poor paper in a typical continental type. However, the reader who is interested in mechanics will not be unduly disturbed by these deficiencies as he discovers for the first time, unless he is exceptionally well-read, just when the ideas so familiar to him first originated, and what were the difficulties which arose in clarifying them. Starting with Hellenic science, the author rapidly passes to the Thirteenth Century (did the Romans really contribute nothing?) and from then on tells a continuous story, even if the manner of its telling somewhat resembles the motion of the grasshopper. To an engineer the most fascinating thread in the story may well be the confusion between energy and momentum, a difficulty which still troubles most schoolboys.

It is interesting to reflect that the theory of mechanics as it is used by the engineer was completed in its essentials by Lagrange, who died in 1813, a fact which is reflected in the teaching of the subject. Anyone who has browsed through old examination papers in engineering will soon have discovered that only those in pure mechanics look familiar to a modern eye, and in reading through this book he will notice with disapproval the omission of any mention of Routh, the Cambridge mathematician who did so much to systematise the essentials of mechanics, and to enlarge the field of study with his work *On the Stability of Motion*. It is curious too to find such scant attention paid to Rayleigh.

With regard to the last long section of this book on modern developments in mechanics, it should be noted that the book contains a flattering preface by de Broglie; but one reader commented that the section may have been written by someone who does not really understand the matter, and that it contains a hodge-podge of the ideas of a few writers of 20 years ago, notably those of de Broglie. Meanwhile, however, de Broglie seems to have altered his position—see the foreword to *Causality and Chance* by David Bohm (1957)! The date of the original French edition of this book does not appear.

It is not clear at whom this book is aimed; no-one who has not a powerful mathematical equipment and considerable knowledge of the subject can hope to read the latter parts, yet a sixth-former would profit from reading the earlier chapters, and it is a pity that the book was not published in two volumes. Nevertheless, anyone who is interested in the origins of engineering science should not fail to look at this book—he will find it well worthwhile.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Medium-batch production on automatic machines. WICKMAN LTD., P.O. Box No. 44, Banner Lane, Tile Hill, Coventry. Illustrated bulletin, punched for insertion in ring binder, giving details of the technique employed by Pollard Bearings Ltd to produce economically batches of components from 100 to 100,000 on Wickman multi-spindle automatics.

Dividing Tables. A. A. JONES AND SHIPMAN LTD., Narborough Road South, Leicester. Precision dividing tables with quick-setting index plates or with vernier scales. 10 in and 12 in diameter tables for mounting either vertically or horizontally, 15 in model for horizontal mounting only. Illustrated leaflet.

Deep Throat Power Presses. E. W. BLISS (ENGLAND) LTD., City Road, Derby. New range of deep throat presses, including bench models of 4 and 7 tons capacity, and floor models from 10 to 60 tons. Throat depth from 12 in on the smallest bench press to 34 in on the largest floor model. Illustrated leaflet.

Threading Machine. MAIDEN & CO. LTD., Hyde, Cheshire. Re-designed threading machine, capacity 4 in diameter pipes or 2 in diameter bolts. Totally enclosed headstock with automatic lubrication, coolant supply equipment, self-centring vice. The machine will cut either parallel or taper threads. Illustrated leaflet.

Tungsten-Carbide Tool Servicing. WICKMAN LTD., P.O. Box No. 44, Tile Hill, Coventry. Wickman-Niven bench-type grinding machine for tungsten-carbide tipped tools. Technical bulletin describing the machine, which has an oscillating head, the tool being stationary.

Oil Gun. STEP INDUSTRIAL EQUIPMENT LTD., The Sawmills, Potters End, Berkhamsted, Herts. Wanner grease guns, hand operated giving pressures up to 5,000 lb per sq. in; and Reilang twin pump oil guns. Leaflets.

Centring on a Lathe. INSLEY INDUSTRIAL SUPPLY CO. LTD., 21/22 Poland Street, London, W.1. "Centri-Vite" centring attachment for centre drilling from the tailstock of a centre lathe, or from the turret head of a production machine. Illustrated leaflet.

Nylon Buyers' Guide. BRITISH NYLON SPINNERS LTD., Pontypool, Monmouthshire. Classified list of manufacturers and merchants of nylon industrial goods, with indexes of brand and company names. Booklet.

Welding Titanium Alloys. WILLIAM JESSOP & SONS LTD., Brightside Works, Sheffield, 9. Information sheet No. M783, punched for insertion in loose leaf folder, gives technical information on fusion, resistance and flash welding of titanium and its alloys.

Boiler Plant Service. N.I.F.E.S., 71 Grosvenor Street, London, W.1. Comprehensive annual service for boiler plant. Pamphlet gives particulars.

Traction Batteries. D.P. BATTERY CO. LTD., Bakewell, Derbyshire. D.P. Kathanode batteries for traction vehicles; cells from 14 to 100 Ah per pos. Sizes and capacities given in leaflet D.P.840.

NEW BOOKS

Technical Reports of the Electrical Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey.

"The Effect of Circuit Resistance on the Discharge Energy Required for the Ignition of Methane Air Mixtures," by H. G. Riddlestone, D/T105 (7*s.* 6*d.*); "Effect of the Cathode Material on the Breakdown Strength of Amorphous Dielectrics," by J. J. O'Dwyer, L/T263 (6*s.*); "The Electron Emission at the Cathode of a Cold Arc," by A. E. Robson, L/T331 (6*s.*); "The Dielectric Properties of Nylon," by E. Rushton and G. Russell, L/T355 (10*s.* 6*d.*); "An Investigation into the Laws Relating to the Rate of Wear and Change of Friction with the Number of Revolutions Performed in Meter Type Bearings," by G. F. Shotter and G. F. Tagg, T/T52 (12*s.* 6*d.*); "The Effect on Electricity Consumption of the Layout of Coal Electric Water-Heating Systems," by M. V. Griffith, Y/T41 (12*s.*).

On the Shelf

By Frank H. Smith

American officialdom seems to have a much better co-operation with industrial organisations than is the case in this country and this remark is prompted by a letter received from the Micro-Photography Co., 97 Oliver Street, Boston 10, Mass., U.S.A. It seems that the United States Naval Research Laboratory indexes some 500 periodicals (ENGINEERING is one) and the entries run into several hundred thousand (subject and author). The original index cards are to be produced in book form by the offset process with 21 cards per page 10 in × 14 in. The firm mentioned will supply particulars and you are warned that the publication "will be available only to those who subscribe in advance of printing, which will start in the 3rd quarter of this year."

Nuclear Review Newsletter is a 5½ in × 8½ in publication consisting of seven pages of snippets of information about matters connected with the implications of the title. Those who believe this to be worth 12·50 dol for 12 issues should write to Nuclear Review, 263 South 21st Street, Philadelphia 3, U.S.A.

I quote: "*The Czechoslovak Mathematical Journal* publishes original research papers on mathematics. Although under a new title, the present journal forms a continuation of the renowned *Casopis pro pestovani matematiky a fysiky* which has been published by the *Jednota ceskoslovenskych matematiky a fysiku* (JCMF) since 1872." Or perhaps you knew all this? It is a quarterly, the rate is 120 kcs per volume and, as far as I can make out, the editorial office is Praha II, Zitna 25, CSR.

Consultants Bureau Inc., 227 West 17th Street, New York 11, U.S.A., have sent us *Express Contents of Soviet Journals* currently being translated into English. This I discovered to be a sample of a monthly publication that the Bureau started in May. In this May number appears all January and February material received by the Bureau by March 30. Tables of contents of the Russian publications covered by the Bureau will thus be given in English to subscribers four to five months after Russian publication. An approximate date will also be given of the appearance of the translation of the item. It must be borne in mind that the service I am describing is Titles Only. To describe the whole set-up would take more room than I can spare. Anyone interested should apply to the address given.

On page 535 of ENGINEERING for 25 April, 1958, I said that the Council for Industrial Design *issues* a . . . catalogue of well-designed goods. The verb should be *maintains* since it is held, as a service, at 28 Haymarket, London, S.W.1. Had I read the handout more carefully I would have seen that the whole purpose of changing the name from *Design Review* to *Design Index* was to remove the idea that the index is a publication. I apologise for the misconception.

The Educational Supply Association Limited, Esavian House, 181 High Holborn, London, W.C.1, are developing a series of "Information Books" which are aimed at helping children to grow up into fairly normal citizens. There are a "People's Jobs" series, a "How Things Developed" series, "How Things are Obtained" series and a "What Can You Find?" series.

The Nickel Bulletin (Mond Nickel's monthly abstract journal from Thames House, Millbank, S.W.1) contains an extended abstract of Sellers and Sanborn's paper "Electroplating on Nickel and Nickel Alloys" in the 44*th Annual Technical Proceedings* of the American Electroplaters' Society. It is considered that this paper is a "miniature handbook on the electroplating of nickel and its alloys. . . ." The *Bulletin* includes three useful tables with its abstract.

Production

SEALED CABINETS FOR RADAR *Complex Production Problem*

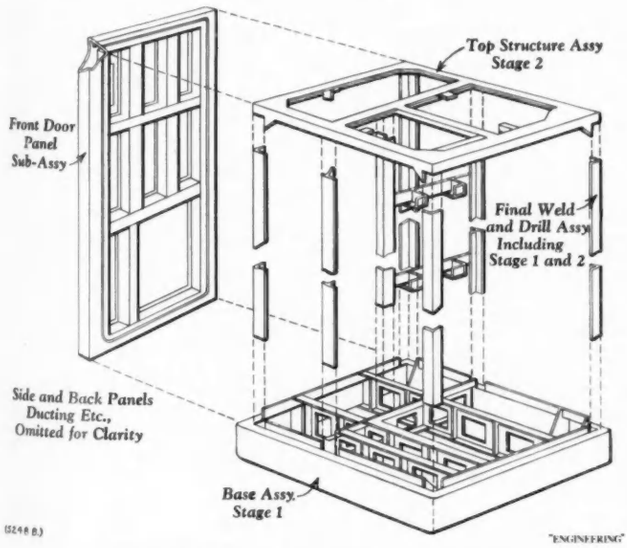
The construction of ten sets of sealed radar cabinets provides an example of work combining the skills of the toolmaker, sheetmetal worker, welder and machinist by an organisation possessing the backing of advanced machinery to give the appropriate accuracy to precision fabrication. Such cabinets were recently completed by Morfax Limited, Willow Lane, Mitcham, Surrey, for Cossor Radar and Electronics Limited.

Each set of equipment consisted of nine cabinets and one base plinth, sub-divided into two categories; one group of four cabinets, to house the radar head equipment, were constructed with mild steel angle and T-section framework and light alloy panels, while the other group, for the equipment-room installation, were constructed entirely from light alloy, as were the plinths on which four of the cabinets in this group were mounted. Construction in each case included a large and varied number of brackets, lugs, trays and sub-frames to accommodate the actual electronic gear, etc. In this respect, no two cabinets in any one set were alike internally.

In addition to the materials for the main structure and panelling, a wide variety of alloys and metals were called for including steel castings, aluminium alloy castings, stainless steel, machined components in gunmetal, and brass castings, together with tin-plate and copper sheet. In all some 3,000 parts were involved in each set of equipment.

Limits of accuracy both for the structure and the location points for the internal fittings are close for this class of work, and the problems were complicated by the fact that the delivery requirement of the first two sets of equipment was extremely short. From the outset, the time factor made special planning imperative and a somewhat different approach from normal was adopted. Interchangeability was achieved by the use of multi-purpose jigs and fixtures. Only " outline " sketches of tools, accompanied by an explanation of their required function, together with component drawings were issued by the planning department to the toolmaking section. Liaison of the individual skills of the toolmaker, sheetmetal worker, welder and inspector, was employed to achieve not only precise, but functional fixtures. A further time-saving factor was the employment of routing machines in the manufacture of component parts in both aluminium alloy and mild steel—this latter application being a departure from normal practice.

Fig. 1 A group of cabinets for radar head equipment undergoing electronic circuit check at Cossor's works.


Top Structure Assy Stage 2
Front Door Panel Sub-Assy
Final Weld and Drill Assy Including Stage 1 and 2
Side and Back Panels Ducting Etc., Omitted for Clarity
Base Assy. Stage 1
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"ENGINEERING"

Fig. 2 Sketch of main structure for radar cabinets.

HEAD CABINETS

The assembly of each radar head cabinet (Fig. 1) consisted of the main structure, cabinet top, side panels, back panels and front door. Together with internal sub-frames and other details, they comprised nearly 300 different parts. The project was planned in five stages: (1) main structure, (2) cabinet top, (3) panels and doors, (4) sub-frames and details, and (5) complete assembly.

The main structure (Fig. 2) comprises a base made from $\frac{3}{16}$ in mild steel in four sections, each of which was formed on a powered brake-press and welded together to form a base shell. Internal components and base stiffeners were then assembled and, by means of location and drill fixtures, were accurately set and welded into the base shell. The same fixture was employed in the final drilling operations to complete the base of the frame structure (stage 1). The work was transferred to a Wadkin router for machining the apertures. Reference to the illustrations will show that these rectangular holes occurred adjacent to double-radius bends, and it was therefore not possible to make them by pressing prior to the forming operation. The routing process offered the greatest precision and economy and eliminated the necessity of uneconomical hand work.

The top of the structure (stage 2) consisted of a frame built up from 2 in by 2 in by $\frac{1}{4}$ in mild steel angles. Here again, a welding and drill jig fixture was employed to locate the angles prior to welding. The two completed sections were then assembled with the main uprights, consisting of 2 in by 2 in by $\frac{1}{4}$ in mild steel angle and T-sections, in the main welding fixture. This fixture was also used for the location of a number of internal details. Certain members of each main structure were common, but the type and location of the internal details were extremely varied. An engraved brass plate attached to the side of the main assembly rig gave the sequence and numbers of the auxiliary assembly jigs to be used for each type of cabinet.

After tack welding, the side of the main welding and assembly jig was detached and the whole structure, measuring 4 ft by 3 ft by 5 ft high, was removed from the jig for completion of the welding operations. Following this, the structure was cleaned, checked and submitted for inspection. Next came the drilling followed by the final machining operations (Fig. 4) on the horizontal borer, Defum CWC 80. Final inspection was then made.

In stage 3, extruded sections were used for the back stiffening frames on all panels and doors; they also housed the sealing gaskets. In most cases extruded sections were cut to length and the ends routed to shape. In the interests of speed and economy, corners of these frames were made common to all cabinets. Press-tools were employed to produce the radius corner inset pieces to conform to the pattern of the extruded section; these insets were welded to the side members after assembling in a fixture.

For the final assembly of panels and doors, an assembly-check and riveting fixture was used with a drill plate for drilling 169 holes of various sizes. All other holes were transferred from pre-drilled holes in stiffeners and back frame members. After dismantling for cleaning, deburring, etc., all internal faces were treated with etch-primer and/or other specified protective compounds. From this point, all completed details and sub-assemblies were then passed to the spray shop for finishing prior to the final assembly.

A similar procedure, stage for stage, was

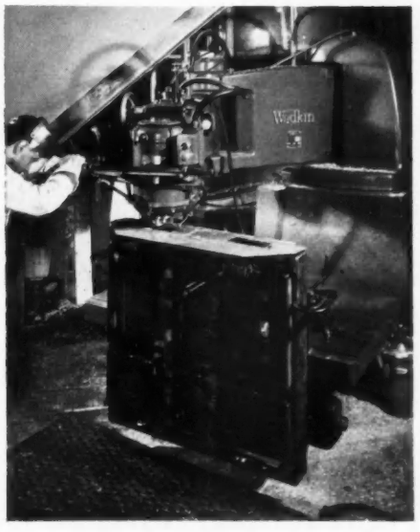


Fig. 3 Apertures being machined in steel base shell by routing machine at 6,000 r.p.m. The equipment shown is a Wadkin L.C. model fitted with a 20 h.p. head.

Continuing Production

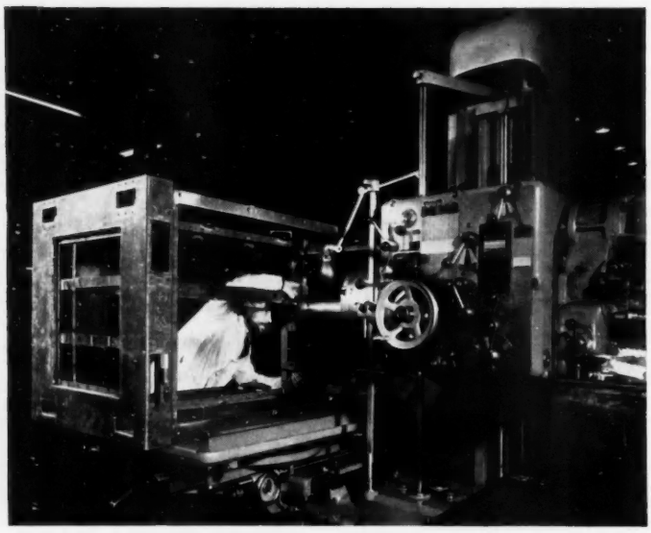
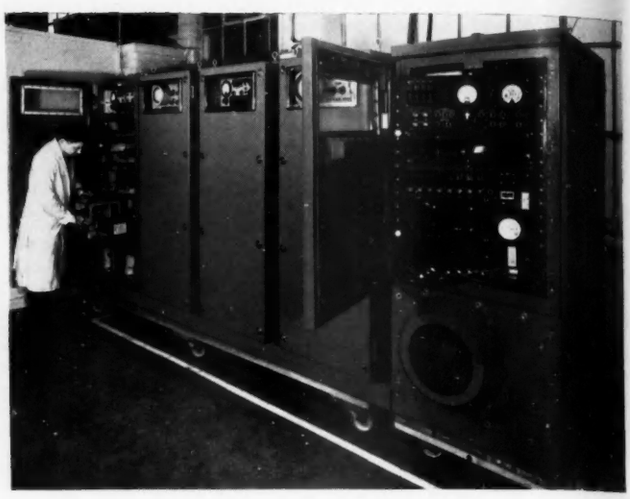


Fig. 4 (above) Main structure of radar head equipment cabinet being machined on a Defum CWC 80 horizontal borer.

Fig. 5 (below) A group of radar equipment-room cabinets undergoing electronic test at Cossor's works. These cabinets are constructed entirely from aluminium alloy.



employed in the construction of the control and cooling system cabinet, except that the top was made from $\frac{1}{8}$ in mild steel and was made integral with the main structure. The light alloy cabinets were fabricated from 10 s.w.g. aluminium, each consisting of two sides, top and two valences for front and back. The sides were guillotined to size, the corners were routed and the drilling operation was carried out prior to the forming-up on the powered brake-press. Similar operations were carried out for the top and valences. Additional welding was employed between the joints of the formed edge of the top plate and the formed top edge of the sides. Extruded sections were used for the doors and panels which were similar in construction to those made for the radar head cabinets—the same tools were in fact used. The cabinets in this group were subjected to a leak test after the shell assembly.

The plinth which formed the base for each group of four cabinets was constructed from extruded channel section (4 in by 2 in by $\frac{1}{4}$ in web) in aluminium alloy. The base plate consisted of a sheet of 10 s.w.g. light alloy welded to the base of the channel sections, and bridge pieces in $\frac{1}{4}$ in aluminium alloy were similarly welded to the top flanges of the channel by the Argon-arc process. On completion, the plinth was subjected to a leak test. In the final assembly, four cabinets were mounted on the plinth which formed a duct for the air-cooling system housed in the end (fifth) cabinet. The connection to the cooling and control unit may be seen in the illustration, Fig. 5.

Problems became apparent during the initial stages of the painting, concerning the application of Rivell surface finish to the exterior of panels and cabinets. Factors which had to be taken into consideration, to obtain a uniform shade and finish on the various materials involved, were the varying surfaces and the different temperatures at which the oven had to be controlled for treating differing materials and thicknesses of component parts.

It is interesting to note that despite the unorthodox methods of planning and tooling adopted for this contract, the high standard of workmanship coupled with rigid inspection enabled the manufacturers to eliminate a complete assembly stage prior to final painting and assembly, thus saving both time and floor-space.

THE FORD THAMES FOUNDRY, DAGENHAM

The modernisation and expansion programme announced in 1954 by the Ford Motor Company Limited, Dagenham, Essex, is now nearing completion, and among these developments is the building and equipping of the new Thames foundry, Dagenham, which produces heavy iron castings such as cylinder blocks, cylinder heads and the larger tractor components. It has a floor area of 533,000 sq. ft, cost £7¼ million and is now in full production. Together with the existing foundries at Dagenham and Leamington, it is intended to meet the increased production requirements resulting from the remainder of the expansion programme.

In design, mechanisation and standard of working conditions, the new foundry is claimed to be superior to any other in Europe and to compare on equal terms with the most modern foundries in the United States. The Thames foundry is planned for a daily output of approximately 400 tons of finished castings, or about half of the total output of the company. It is manned by 1,800 operators and the output per man-hour of the particular types of castings involved is twice that achieved under previous methods of manufacture.

As stated in a previous article on the Thames foundry, which appeared on page 701 of our issue of 29 November, 1957, the two parallel buildings constituting the new foundry are built on piles on a 22-acre plot of land and, running between them, are enclosed high-level conveyor passages. A plan of the first or main operating floor of the foundry is seen in Fig. 1. The main building measures 1,200 ft in length by 180 ft in width and has a height of 70 ft, and in it the principal foundry operations of melting, moulding, core-making and fettling are carried out. The adjoining ancillary building, measuring 700 ft by 60 ft by 70 ft, contains the sand-handling and drying and the casting-cooling, grinding and cleaning sections. The ground floor of the main building contains the maintenance equipment, the offices and stores, and the canteen, showers, lockers and other amenities for the employees.

An outstanding feature of the new foundry is the heating, ventilating and air-purifying system, which warms the building and changes the entire air content more than 7 times an hour, and, in the moulding and fettling departments, as many as 16 times an hour. All air entering

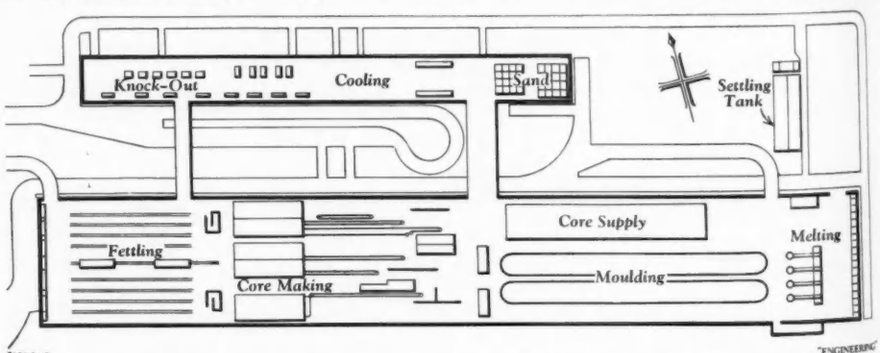


Fig. 1 Plan of the first or main operating floor of the foundry building. It is 1,200 ft in length and 180 ft in width and is connected by enclosed high level conveyor passages to an ancillary building running parallel with it.

Fig. 2 (left) Part of one of two hot-blast plants applied to two of the four 108 in diameter cupolas. The recuperator is seen in the centre on the left and the combustion chamber in the centre on the right.

Fig. 3 (right) Part of a core-making line equipped with six core-blowing and core-stripping machines. Four of these units are fully automatic and two are semi-automatic, the latter producing the heaviest cores.

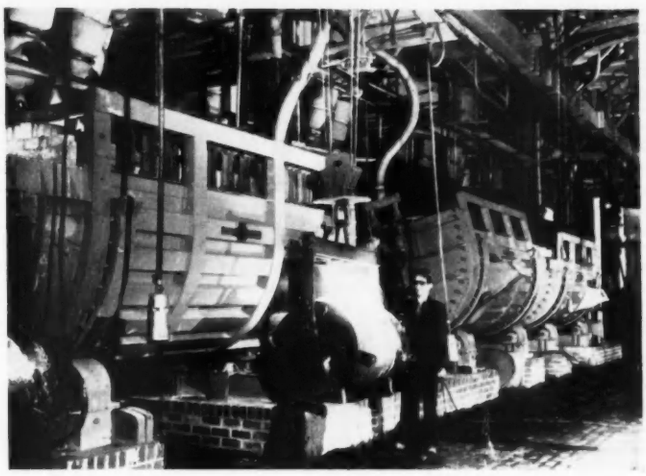


Fig. 4 (centre right) Four 8 ton capacity hot-metal receivers into which liquid cast iron is poured from the four cupolas. Here metal is being transferred into a 2,000 lb ladle for conveyance to a pouring station.

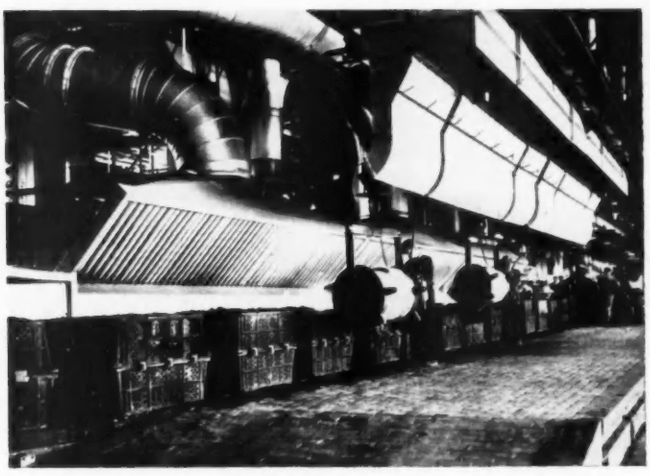


Fig. 5 (lower right) Pouring heavy castings on one of the two pouring lines at the Thames foundry. Above is the smoke and fume extraction system which ensures good working conditions.

the building is cleaned and warmed in winter and fan-cooled in summer. Special dust-extraction systems collect suspended matter at the source and deliver it by ducting to wet-type separators. A sluicing system receives the slurry produced, together with slag from the cupolas, and carries these materials to settling tanks and ponds. The water is then returned for re-circulation.

The melting plant consists of four 108 in diameter coke-fired hot-blast water-cooled cupolas fitted with skip chargers. There is one hot-blast unit to each pair of cupolas and part of this section of the plant is seen in Fig. 2. The hot metal from the cupolas is poured into four 8 ton receivers, one to each cupola. The receivers are seen in Fig. 4, which also shows hot metal being transferred into one of ten 2,000 lb ladles. These are suspended from monorail electric towing and hoisting gear and convey the molten metal to the moulds at the pouring stations. Four 1,000 lb ladles are also available and a 20 ton per hour pig-casting machine is brought into operation when surplus metal has to be handled.

The two moulding lines in the foundry are fed from their own automatic sand systems and are fully equipped with smoke and fume-collecting apparatus. Each line incorporates eight semi-automatic jolt-squeeze straight-through type moulding machines working within a continuous 800 ft mould conveyor of the latest pallet design. There are four cope and four drag moulding machines on each moulding line. Cores are formed and baked at least 24 hours ahead of the moulding process. The core shop, as will be seen in Fig. 1, is centrally situated in the main building. The core sand is mixed at a central high-level station and this operation is completely automatic. It is worked by the insertion of a punched card into the weighing system, one card for each type of sand mix. The mixed sand is conveyed by two pneumatic systems to the core-making machines. All the cores are made in fully and semi-automatic vertical core-blowing machines of which there are 39 in all. The cores are taken by conveyor to five continuous horizontal ovens for baking. These are built at an elevated level to facilitate operations and to provide storage space beneath them. After delivery from the ovens, the external faces are coated with a special wash and the cores are finally dried in three horizontal core-wash drying ovens. Nine core-grinding machines are available to remove surplus sand.

After pouring, the castings are removed from the drag portion of the mould by means of special hook carriers suspended from a monorail conveyor running vertically above each mould conveyor. The castings proceed to the adjoining ancillary building by way of the right-hand conveyor passage in Fig. 1. After cooling for some three hours, the moulding sand and the cores are removed in the knock-out section by vibrators and the castings are passed through a battery of grinding machines which remove any metallic surface irregularities. The castings then return to the main foundry building on two monorail-type conveyors by way of the left-hand conveyor passage in Fig. 1. They are finally cleaned ready for machining in eight fettling lines and, where this may be required, submitted to a water test.

The steam and gas mains and the power cables all follow the line of a common trestle-way to the new foundry from the company's own power house and coke-oven plant, a distance of half a mile. A main road joining the Thames foundry site to the Southend Road (A13) is carried northward over a new railway bridge and a new connecting road eastwards runs over the River Beam to the foundry. In addition to the roads, nearly a mile of new railway lines and sidings have been constructed for the transport of raw materials.

The design and layout of the new foundry is the result of an exhaustive study of all the principal foundries in Great Britain, Europe and North America. It is of interest to note that the company's own civil engineers have been responsible for the buildings and have provided a good example of modern industrial architecture.

In spite of periods of national emergency and material shortages, the new foundry has been built in record time, the first pile having been driven in March, 1955.

Construction

WEIGHT-SAVING IN STEEL STRUCTURES

Every two years the West of Scotland Iron and Steel Institute holds a conference to discuss aspects of the metallurgy, mechanical properties and applications of iron and steel. The conference, which took place on this occasion on 16 May in Glasgow, was concerned with the metallurgical and engineering aspects of weight-saving in steel structures. The seven papers are discussed below, paper by paper.

The paper on the plastic theory, " Approximations to Material Properties in the Plastic Theory of Structures," by Dr. M. R. Horne and Mr. T. M. Charlton, is concerned with explaining the significance of the simplifying assumptions made for the purpose of the plastic theory and the limitations on the theory imposed thereby. Thus, since rigid-plastic behaviour of steel is assumed, the effects of elastic deformations, the slenderness of members and stability generally, the upper yield point, initial stresses and strain hardening are considered. It is argued that the effects of elastic deformation and frame slenderness upon collapse behaviour are usually very small for single-storey frames: curves showing the reduction of theoretical collapse load due to elastic deflection and frame slenderness, respectively, for a simple portal are given to substantiate this viewpoint. The authors note, however, that the effect of deflections is likely to be more important for multi-storey frames, but state that for typical unbraced frames of up to six or seven storeys the reduction in theoretical collapse load would be less than 10 per cent. The difficulty of making generalisations concerning multi-storey frames at the present time, owing to the existence of stability problems for this kind of structure, is acknowledged. It is shown by considering the behaviour of simple beams, that the effect of the upper yield point is to cause a closer approximation to rigid-plastic behaviour and that initial stresses do not affect the plastic collapse load. The effect of strain-hardening, which follows yielding, is dealt with finally and it is shown that, provided the ratio of the strain at which strain hardening begins to that at which yielding first occurs is greater than about 8 (as is usual for mild steel), the moment of resistance at a plastic hinge in a beam will not exceed the theoretical value by a significant amount. It is noted, moreover, that strain hardening has the advantageous effect of lending stability to the plastic condition. The authors conclude that, at least, the idealised plastic theory enables an economical preliminary design to be obtained.

COLD-FORMED STEEL SECTIONS

In their paper " Applications of Cold-Formed Sections," Dr. R. M. Kenedi and Mr. W. Shearer Smith consider the manufacture, behaviour and design (in that order) of cold-formed structural members together with the economic and practical aspects of their use in structures. It is noted that these sections can be made from " high-strength " steel, stainless steels, aluminium alloys and copper alloys as well as mild steel. The variation of the mechanical properties of material following cold forming, in comparison with those of the parent strip, is described with diagrams, and the existing practice of basing design stresses on the latter is deprecated as being irrational. This is followed by consideration of the behaviour characteristics and design of cold-formed members. It is noted that while the design problem is essentially the same as that for the thicker hot-rolled sections, there is necessarily a change of emphasis. Thus, the stability aspect assumes greater importance and, owing to the probability of local instability, plastic hinges are unlikely to develop fully in members of ductile material. Appropriate stability criteria are considered in some detail. In dealing with the important question of economic design and optimum proportions for sections, the emphasis is on minimum weight as one of the conditions of low overall cost, and it is suggested that weight-saving is synonymous with structural efficiency defined as the load carried per unit weight of structure. The design of struts is selected for detailed consideration and a combined efficiency and design chart for concentrically-loaded struts is described. The authors make a point of advocating the use of charts of this kind in structural design. In connection with the aspects of fabrication and protection against corrosion, it is stated that a variety of established welding techniques are commonly used for fabrication, but bolting or riveting can be used also; protective treatment can be applied either to the parent strip or the formed sections or the fabricated structures. Various processes, including galvanising, are considered briefly; the most satisfactory treatment at a reasonable cost is stated to be phosphating followed by painting. The importance of detail design, bearing in mind requirements for satisfactory protection, is emphasised.

" Cold-Roll Forming Practice in the United States " is the title of the paper by Mr. W. G. Kirkland of the American Iron and Steel Institute. Confining attention to steels, but noting that any ductile material can be successfully roll-formed, it is stated in the introduction that mild-steel plate as thick as $\frac{3}{4}$ in can be used, while stainless steels have been roll-formed in thicknesses as great as 0·30 in. The main advantage of this process is given as economy due to high production capacity but another desirable feature is that two or more materials, such as wood and steel, can be fed into a roll machine to form a single product.

After describing in some detail typical roll-forming machines and the material and preparation of the rolls themselves, including oil-hardened tool steel with ground finishes, the importance of pre-planning is considered. The necessity of close collaboration between the product and roll designers is emphasised having regard to the question of tolerances and the elimination of unnecessary complications of form, in the interests of economy. The most important aspect of roll design is stated to be the planning of the successive intermediate shapes of the material to obtain the smallest number of roll passes to achieve a desired form. The author proceeds to consider alternative approaches to roll design and emphasises the importance of experience and judgment: the " forming angle " and " flower " methods of design are described. Then accessories for guiding material through rolls and assisting in forming, and the use of idle rolls for supplementing the function of the main rolls, are described. Auxiliary equipment for straightening the finished product as it emerges from the rolls and for operations such as coiling, punching and marking is dealt with briefly and the final paragraphs of the paper are concerned with the tolerances obtainable in roll-formed sections, " spring back " caused by rolling, lubricants for roll forming and the re-forming of lock-seam tubing.

HIGH-TENSILE STEELS

The two papers on low-alloy high-tensile steels are by Mr. I. M. Mackenzie and Mr. G. Roberts; their titles are, respectively, " The Application of Low-Alloy High-Tensile Steel " and " Structural Uses of Welded High-Tensile Steel." The former is concerned with seeking an explanation of the failure of low-alloy high-tensile steels to compete with ordinary mild steel for the majority of structural applications. The factors examined are design stresses, fabrication problems, availability and cost. It is suggested that where codes of practice are based on ultimate strength rather than yield stress, the use of low-alloy steels appears to offer little advantage over mild steel because their ultimate strengths do not differ greatly, but if yield is the criterion the case for these steels is enhanced considerably. Attention is called to the practice in this country of using ultimate strength as the basis of pressure-vessel design and yield stress for the design of structural steelwork. It is also noted that if working stresses are limited by considerations of rigidity, corrosion wastage, fatigue or brittle fracture, the use of low-alloy high-tensile steels is not advantageous in comparison with mild steel. In addition, the problems of fabrication by welding, associated with the use of high-tensile steel such as the necessity of using low-hydrogen electrodes or preheat, are outlined and the unfavourable nature of the availability and cost aspects are discussed. Exceptions are made regarding carbon-manganese steels covered by B.S. 548 and 968, in respect of the cost aspect, but at the same time it is stated that the former has been officially condemned for inadequate weldability. It is concluded that the use of low-alloy high-tensile steels might be justifiable where reduction of weight of the structure can lead to substantial reduction in either capital or operating costs, but that until the cost of alloying elements is reduced, more general abandonment of mild steel is unjustifiable.

WELDABILITY

In his paper, Mr. Roberts suggests that among the most important factors in weight-saving and economy in steel structures are the use of higher quality material and the substitution of welding for riveting. After considering the development of structural high-tensile steel with the requisite ductility, such as that embodied in B.S. 548 (maximum carbon content 0·30 per cent) which is only 20 per cent more costly than mild steel for an increase in yield point of 50 per cent, the further problem of high-tensile steel suitable for welding is considered. It is stated that the original proposal contained in B.S. 968 for such a steel was unsatisfactory for general use, owing to the marked deterioration of its strength properties with increasing thickness of rolled plate and sections, even though its maximum carbon content of 0·23 per cent made satisfactory welding, without cracking, relatively easy. The author describes his selection of an alternative without this disadvantage, for the welded columns of the Braehead power-station structure. The choice made was for a steel to B.S. 548 but with a maximum carbon content of 0·26 per cent, which as supplied by the steelmakers had 0·25 per cent carbon, even though they were unable to guarantee the restriction on carbon content. The minimum yield point obtained in the $1\frac{5}{16}$ in thick plates was 22 tons per sq. in and the welding was carried out without difficulty. It is stated that subsequent research has shown that successful welding of high-tensile steels depends on the use of a welding procedure which ensures the requisite heat conditions to prevent cracking and that carbon content is not the critical factor, as was thought to be the case originally. A specimen diagram for applying the criterion of weldability to steel to B.S. 968 is given and its adaptation for steels with a slightly higher carbon content is considered briefly. Examples of some recent successful applications of welded high-tensile construction are given, including the 800 ft span arch bridge over the River Volta in Ghana and the jib of a derrick crane. For these kinds of construction the saving in dead load can lead to economy owing to the total saving in weight of material.

TUBULAR CONSTRUCTION

In a paper on tubular construction, " The Application of Tubes to Structures," by Mr. G. B. Godfrey, the advantages of structural members made of tubes are considered. It is claimed that cumulative savings in tonnage due

to tubular construction which are possible when it is appropriate, ranges between 30 and 50 per cent in comparison with conventional steelwork. After some introductory remarks referring to early examples of the use of large tubes as main compression members in bridge construction (such as the Forth and Menai bridges), the properties of tube steels are described and the current use of ductile high-tensile weldable steel having a yield point of 20 tons per sq. in is emphasised. The difference in cost between tubes of this material and those made of mild steel is stated to be small. After considering the commercial range of tube sizes (such as seamless tubes up to 18 in outside diameter and welded tubes of larger diameter) the aspect of weight saving in structural design using tubes is dealt with. Examples of the form of economic tubular construction, such as lattice principals and purlins, are given and the behaviour of tubes in tension, compression, torsion and flexure are discussed. Curves comparing the capacity of a tubular strut with those of similar weight in the form of standard rolled steel sections are given. With reference to joints, it is stated that the majority are made by preparing the end of one tube so that it can be welded directly to another. Special arrangements and junction boxes involving flanges on tubes and high-tensile steel bolts, which have been used when a large number of members meet at one point are illustrated. The remainder of the paper is devoted to the important aspects of corrosion resistance, reduction in wind loading and in dead loads afforded by tubular construction, the development of rectangular hollow sections for structural work, the use of prestressing wires inside tubes and composite construction with tubes. Concerning corrosion protection, it is stated that sealing renders the internal corrosion of tubes negligible.

MILITARY BRIDGES

The seventh and final paper considered at the conference was "Weight-Saving in Military Steel Bridges," by Mr. A. E. Long. It reviews progress since 1937 in achieving weight reduction in military-bridge construction as an essential feature of improvement of this kind of structure, since mobility and speed of erection are basic requirements. Bridges described include the small and large box-girder type, unit construction (Hamilton) bridge, the Inglis bridge (having trusses made of tubing), the Bailey bridge, tank-launched bridges such as the "scissors" type and the Churchill bridgelayer, floating bridges, suspension bridges and railway bridges. The use of weldable high tensile steels to B.S. 548 and 968, with minor modifications, in some of these bridges is described. Steel to modified B.S. 968 has been used for the Bailey bridge and the possibility of prestressing this type of bridge to advantage is also discussed briefly.

A testing rig capable of applying concentrated dead loads up to 250 tons to full scale structures for investigating actual factors of safety, is described briefly. It is concluded that there is still much scope for reducing the weight of military bridges by making more extensive use of high-tensile steel suitable for welding, but the availability of such steel is poor. A plea is made to steelmakers to rectify this situation on the grounds that there is a large potential market for such material. It is, moreover, suggested that unless the steelmakers take advantage of the present demand by concentrating less on quantity and more on quality, it is possible that alloys will become a powerful competitor of steel in the constructural field.

During the course of the discussion of the seven papers taken *en bloc*, the irrationality of designing on stress criteria for safety was suggested because of the frequent impossibility of predicting total stresses. The use of the plastic theory for ductile materials was proposed as the means of overcoming this difficulty as well as achieving economy, since it can, in any case, be used as a means of producing a trial design. The poor availability of weldable high-tensile steels was questioned and it was stated by representatives of steelmakers that these would be made available if there were a sufficient demand for them. There seemed to be a substantial body of opinion which regarded the greater use of high-tensile steels as desirable in the interests of weight-saving and economy. A variety of novel tubular structures in Germany were illustrated by lantern slides in support of the case for the economic advantages of this form of construction.

AIRBORNE CRANE PLACES BEACON

Recently a Westland S-55 helicopter of British European Airways undertook one of the most skilful precision flying operations ever attempted in the United Kingdom. The operation involved placing a rotating light beacon, weighing half a ton, on to a tower 85 ft high, located in wooded country three-quarters of a mile from Gatwick airport.

The helicopter was flown from its base at Gatwick to the Stone-Chance factory at Crawley, 1½ miles away. The beacon, in two sections, was loaded on board and flown to a field adjoining the 85 ft tower, where the two portions were unloaded.

The base was placed on a winch on the side of the helicopter, which then took off; it was lowered on the tower, where two men were waiting to secure it. On a second flight, the beacon itself was located on its base on the tower, a delicate task involving the alignment of the securing bolts and bolt holes on the beacon and tower.

By using the BEA helicopter as a mobile crane, a tricky task which might otherwise have involved cutting a path through the surrounding woods, was completed in less than 30 min.

PROGRESS WITH PRESTRESSED CONCRETE

The increasing interest in prestressed concrete was amply illustrated by the large number of participants at the Third Congress of the FIP and also the wide range and variety of the many papers submitted for discussion. There were about 1,200 registered members of the Congress and the technical sessions were exceedingly well attended.

The technical work of the Congress was divided into four sessions dealing with (I) development in design methods, (II) progress in site techniques, (III) progress in the manufacture of factory-made pre-cast prestressed concrete units and in their use and assembly on site, and finally (IV) structures executed wholly or partly in prestressed concrete since the 1955 Congress.

MULTIPLE STRESSES

The main theme in Session I was that of the determination of the strength of prestressed concrete units under the action of combined stresses. Several papers were presented on the ultimate strength of prestressed concrete beams in flexure; these tended to favour the use of only the equilibrium condition and to ignore the compatibility of strains. This simplification can lead to serious error in the determination of ultimate moments and the general reporter, Professor H. Rüsch, stressed that the strain compatibility condition was essential to ensure a satisfactory interpretation of the behaviour of prestressed concrete.

The problem of shear strength was discussed in many papers and several empirical formulae were put forward which, while satisfying the small groups of beams tested, were not valid for other series of tests. This anomaly arises because of the varying differences of opinion on the definition of shear failure and hence different views on the interpretation of test results. Professor Rüsch brought this point clearly to the notice of Congress by listing the empirical formulae at present available for shear-strength calculations.

This subject of shear is one on which a great deal of truly fundamental research has yet to be done; a study of concrete under triaxial stresses, in pure shear, etc., is essential before any further progress can be made in the formulation of methods of calculating the shear-strength of beams. Considerable attention is being paid by research workers to this problem but there is a great necessity for international co-operation in this field since the numerous facets of the problem must be explored in a systematic manner so that all the information from the numerous tests can be correlated.

The problem of the torsional strength of prestressed concrete has received very little attention and, apart from work described in a paper by Professor Henry J. Cowan, very little work on this problem is now in hand. However, in the discussion a series of tests on rectangular prestressed beams carried out by the Cement and Concrete Association in England was described. This work is continuing with tests on beams of other cross-sections and on hollow cylinders.

SITE PROBLEMS

Session II dealt with the practical problems of prestressed concrete, in particular with grouting, friction and anchorages. The papers on grouting reflected primarily the national tendencies associated with the main systems of prestressing. This problem is becoming increasingly important with the introduction of load-factor methods of design and this was evident in the lively discussion that followed Dr. C. F. Janssonius' general report. The use of aluminium powder as an additive to the grout was contested on the grounds that its inhibiting effect on the shrinkage was not effective in the confines of a fine duct. Against this should be set the increased fluidity that can be obtained in certain circumstances. Recent work in the United Kingdom has shown that, with adequate supervision and appreciation of the problem of grouting, efficiency can be achieved in almost any type of duct. What is needed is a simple method of obtaining this efficiency under the infinite variety of site

Continuing Construction

conditions met. Friction in post-tensioning systems was dealt with by several papers reporting laboratory experiments, but a truly theoretical approach was not forthcoming embracing the many factors involved. This subject is again one where site supervision is necessary to either check or modify design requirements.

The multiplicity of anchorages now available to the design engineer was further increased by new types put forward in various papers and also by the interesting exhibition of prestressing systems at the Congress. It is inevitable that new equipment be introduced, but it would seem desirable that in the near future some standardisation should be achieved.

PRE-CAST CONCRETE

The two topics of particular interest in Session III were those of mechanisation in the production of factory-made units and the problem of transmission length in pretensioned concrete. The work in Russia, described by G. Berditchevski, A. Svetov and B. Sklyar, is of interest in that mechanical handling of the wire to both stress and position has been very far advanced and some degree of automation introduced. This has been possible by imposing a limit on the number and type of units produced—a process only suited to countries where the demand for standardised buildings is on a sufficiently large scale. A film of a number of pretensioning factories in Russia admirably brought out the points mentioned in the paper. The use of pretensioning strands laid to a profile was illustrated by B. C. Gerwick of the United States; the production techniques involved were well illustrated by slides of the manufacture of large pretensioned bridge beams.

The two papers dealing with transmission length, by G. D. Base and by E. H. Ratz, M. M. Holinjanski and V. M. Kolner, are among the first to appear on this important topic. Base reported work carried out on factory-made units and his was, essentially a paper dealing with the actual transmission length observed in factory-made units. On this basis limits to the transmission were assessed in relation to the size of wire used. The effect of indentations on the wires (as used in England) was shown to be insignificant, whereas the effect of crimping was shown to be of great importance in achieving short transmission lengths. The other paper dealt with the theoretical approach to transmission lengths and evolved an expression enabling the transmission lengths to be estimated. Laboratory tests were used to establish the validity of the expression. It was found that indentations had a significant effect; this was because the indentations used were much deeper and were formed by a process which virtually gave a ribbed surface to the wires. Both of these papers merit a close study in view of the high bearing and shear stress usually present within the transmission zone of pre-cast prestressed units.

Session IV was, unfortunately but inevitably, too short to enable full justice to be done to the structures described. However, those shown and described must have stimulated the Congress considerably by virtue of their ingenuity of conception and execution. The vast number of bridges described indicate the increasing use and economy of prestressed concrete in this field. From so many examples it may be invidious to select any particular one, but an elevated water tank in Sweden comes to mind as being characteristic of the elegance and simplicity that has been achieved by the use of prestressed concrete.

Engineering at Home

RADIOPHONY

The BBC have recently set up a radiophonic workshop at their Maida Vale studios. It is used to produce sounds synthetically, either by the electronic modification of natural sounds or by the modification of sounds generated electronically. The techniques used are similar to those employed in the production of electronic music (ENGRG., p. 160, 31 Jan. '58), but short " effects " are produced rather than complete works. " Radiophonic Sound " is the name the BBC give to such effects.

Magnetic tape recorders are the focal point of any studio equipped for such effects. At Maida Vale a two-machine channel for recording and reproducing has been installed. This unit has been designed to full professional standards, for a tape speed of 15 in per sec. There are also two smaller machines with variable speeds; and a disc recorder and several other rehearsal tape recorders are available. An artificial reverberator has been designed by the BBC research department and installed in the workshop. It uses a number of reproducing heads situated around the circumference of a revolving plate coated with magnetic material. Accurate delays are possible over a wide frequency range.

A feature of the workshop is the control panel and jackfield that enables any piece of apparatus to be cross-connected or combined with the mixer-control panel. In the illustration, the jackfield can be seen on the left and the reverberator occupies the centre background. The equipment is used for special effects suggestive of an emotion, sensation, or mood.

The view from the adjacent studio shows the control panel of the radiophonic workshop on the right. The tape recorders are on the side of the room, out of sight, behind the control panel.

STUDYING HEATING

The annual report of the Electrical Research Association Laboratory, Leatherhead, Surrey, mentions, in one of its sections, the present state of work being carried out on heating. Floor heating tests under winter conditions have been conducted in the laboratory's controlled-environment test room. These tests include a study of the effects of position and quality of thermal insulation, and other characteristics of heated suspended floors. Comparative tests on directly buried and withdrawable cables show no difference in thermal performance.

Tests on floor-heated buildings are being continued. They are concerned with transient heat flow in multi-storey flats, and the investigation of some unusual performance characteristics of certain floors in commercial buildings. The full-scale investigation of the floor heating systems in highly-insulated CEA houses at Keadby is nearing completion.

Heat flow meters of various types, which can be used with confidence, have been developed for use both in outside tests and in the laboratory. The investigation of the comparative effects of air movement and air temperature on the rate of drying of domestic laundry is nearing completion and the results will be correlated with the performance characteristics of various commercial cabinets.

The performance of special evaporators, built according to recommendations arising from laboratory investigations of the effect of frost depositions on heat transfer, has been studied during tests on domestic heat pumps.

DOUBLE TAKE

The massive items of equipment associated with atomic and rocket research play a large part in a cinema phantasy being filmed in Russia. But the technical methods used to make the film are themselves an innovation. The double-reel technique, as it is called, is still in its experimental stages, but it allows actors to be photographed separately from their setting.

The actors are photographed by two cameras as they act their parts in front of a screen emitting infra-red radiation. One reel of film gives the usual coloured images of the actors, without any background; the second gives their opaque silhouettes, also without background. While the setting is being filmed, the second reel, with its silhouettes, is synchronised with the film in the camera so that blank spaces are left on the negative. The coloured images of the first reel can subsequently be fitted into the blank spaces.

Besides being economical and convenient, the new method opens up new creative possibilities for film makers. In the film at present being made, tentatively called " Man, Friend of Man," there will be Japanese dancers performing the " Dance of the Goldfish " at the bottom of the sea. Also artists from Colombia will do a Negro dance with drums, the drums being accompanied by a huge organ that towers over the city like a skyscraper. In point of fact, the " organ " is a rocket launching ramp. Electronic music is used and a proton-synchrotron will also be featured. The film ends with a chorus singing songs in 30 languages as they float down Moscow River to the Kremlin.

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